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THE WEDDELL SEAL IN THE BAY OF WHALES, ANTARCTICA

BY ALTON A. LINDSEY

Despite its great abundance on Antarctic coasts, the Weddell seal (*Leptonychotes weddelli* Allen), until the turn of the century, was one of the most imperfectly known of described mammals. Discussing the "Belgica" collections, Barrett Hamilton (1901) stated: "Amongst the greatest rarities are four skulls, a skeleton, and two skins of Weddell seal. Of this species the British Museum possesses only four skulls, but two are imperfect." Later (1902), in tracing the history and taxonomic vicissitudes of *Leptonychotes*, the same author remarked: "Practically nothing is known of the habits of the Weddell seal."

That the technical description of the species is now fairly complete is due to the work of Turner (1888) and Thomson (1915) on its osteology; Hepburn (1915) and Haig (1915) on the anatomy; and Tims (1910) and others on the embryology.

Dr. Edward A. Wilson, who lost his life with Scott on the return from the south pole, in 1902 made the first serious investigation of the life history of this seal. Included in his splendid report on Antarctic vertebrates, the account furnished a broad outline as a good foundation for further work.

During the first Byrd Antarctic Expedition, P. A. Siple recognized the desirability of an intensive study of the Weddell seal, and he initiated such a project during the summer of 1929–1930 in the Bay of Whales. During the second Byrd Expedition, the summer of 1934–1935 was devoted by the present writer largely, and the preceding 8 months in part, to this work. His thanks are extended to Rear-Admiral R. E. Byrd for leadership to the Antarctic, to P. A. Siple for unpublished notes of 1929–1930, generously made available, and for his reading of the manuscript; to Dr. T. C. Poulter for his friendly interest and help at the field base; to Dr. H. E. Anthony for use of the facilities of the American Museum of Natural History, where the collec-

tions are deposited; to Dr. J. Eric Hill for orientation in osteology; and to Robert Young of New Zealand for faithful assistance in the labor of weighing live seals.

The position of the expedition's base camp was Lat. 78° 34′ 5″ S. Long. 163° 55′ 56″ W. Observations of *Leptonychotes* covered 50 square miles of the bay's surface lying west, south-west, and north of the base. In the northern two-thirds of this area, as well as in the pack ice east to Long. 116° W., the crab-eater seal (*Lobodon carcinophaga* Gray) was observed and collected in the summer months. No Weddell seals were seen in the Antarctic pack, for this species is coastal in distribution.

ADULT SIZE

Wilson's observations in McMurdo Sound at 77° 50′ S. led him to attribute variations in size to age rather than to sex difference, although no measurements in the flesh were reported (1907). Because of the need of the Byrd Expedition for a large number of seals as dog food, many more individuals were measured than the 43 that were collected for museum specimens. All large individuals that were found during a hunt were taken, for these furnished most meat; but all available seals were killed regardless of size except the young of the season, few of which were taken for this purpose. On the ice the Weddell seal is unfitted both by disposition and physique for escaping a human hunter. The Bay of Whales is isolated from the nearest seal-inhabited inlet along the Ross Ice Barrier cliff by 24 miles of open water ranged by the killer whale (*Orca gladiator*). The Weddell's preference for fast bay-ice is well proven. Moreover, the animal has not been shown to be migratory, although the colony in this bay dwells farthest south of all mammals. Seals were taken at many different points throughout the bay. Often they were located for us by the aviators. These facts seem to justify the belief that the data secured are truly representative of the seal population in the area studied.

From February 9 to March 17, 1934, 233 Weddell seal carcasses were measured. Fig. 1 presents the frequency distribution, each column indicating the number of individuals falling within a two-inch class interval unit. All length measurements in this paper refer to distance from tip of nose to tip of tail, not the over-all length to the end of the rear flippers. The tail is short, averaging 3 inches.

In computing mean length, the season's young, about 4 months old and less than 77 inches long, were omitted. The mean length of the 93 males over 13 months old was 94.12 ± .46 inches, while 124 such adult and adolescent females averaged 96.46 ± .45 inches. The difference in the mean length of the sexes therefore was 2.34 ± .64 inches. Since this difference is 3.7 times its probable error, it appears that there may be a significant difference favoring the females. There were 15 females larger than the largest male.

At the South Orkneys, Bruce (1915, p. 166) collected 6 adult males and 11 adult females, the maximum nose-tail lengths being 104.5 and 115.5 inches respectively. Of his 17 specimens, 5 females were larger than the largest male.

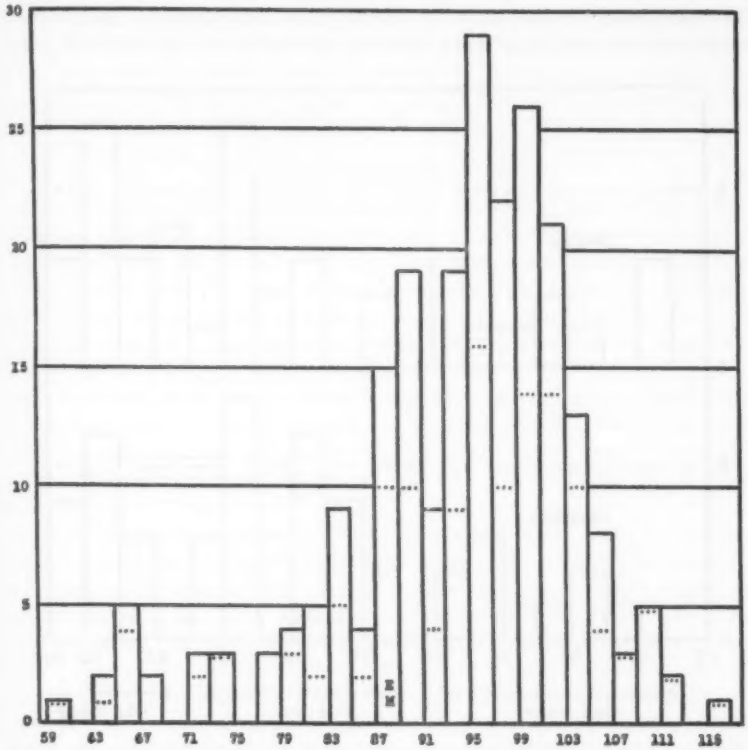

FIG. 1. Frequency distribution of nose-tail length measurements of 233 Weddell seals measured February 9 to March 17. Class interval, 2 inches. Males above the dotted lines; females below. Abscissae, number of animals; ordinates, their lengths.

BREEDING AGE AND GESTATION PERIOD

The data in figs. 1 and 2 enable us to define the annual age groups in terms of size for adolescent seals of different ages. Since all the young of each season are born within about one month, and the period during which we measured seals was similarly restricted, these frequency distribution charts show a drop to or toward the base line between adjacent annual age groups.

Their interpretation has been supplemented by field observations, skull data, and the skin series, and the conclusions are indicated in fig. 2.

The two smallest females that contained embryos were 87 inches long. Other small pregnant females measured 88, 89, 91, 94, and 95 inches. Fig. 2 indicates that the very youngest pregnant seals are in their third year. This establishes the fact that the female when two years old has reached sexual maturity and may mate, gestation occurring during its third year,

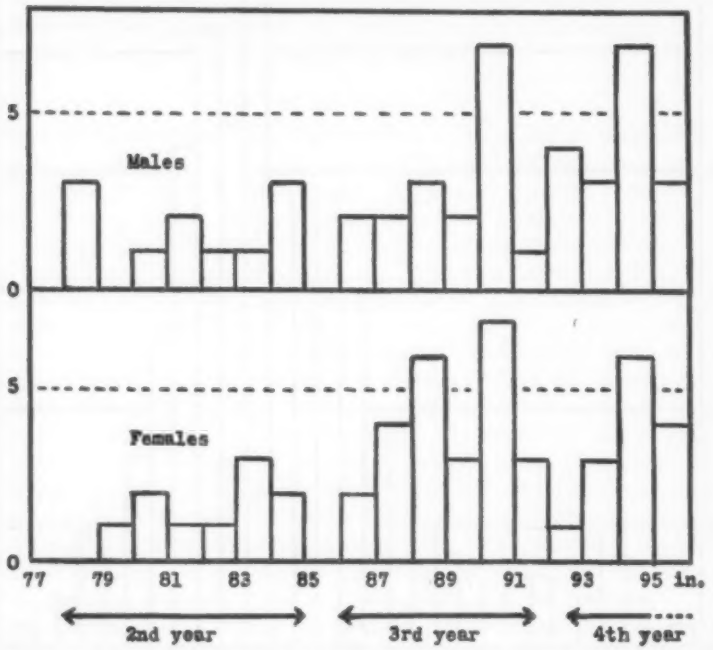

FIG. 2. Frequency distribution of lengths of seals in their second, third, and fourth years, measured February 9 to March 17. Class interval, 1 inch.

and the first parturition when it is barely three years old. Apparently mating has not been observed; presumably it takes place in the water. Wilson (1907, p. 19) wrote, "The gestation period is as nearly as possible eleven months." He added (p. 20) that the rutting season follows directly upon the separation of the young from their mothers. Brown (1915, p. 190) considered gestation to last "probably eight to nine months."

Forty-four births of known date were recorded, from October 5 to November 10, in the rookery studied, including both 1929 and 1934 seasons.

The median date is October 23; also the median birth occurred on this date. Since small embryos were found as early as the latter part of January, the gestation period seems to last over 9 months. The rarity of bulls in the central and southern parts of the bay (where the rookeries occur) while the mothers and pups are together, may aid in setting its maximum. Eighteen of the dated young were traced through the time of permanent separation which occurred on the average at 50.3 days after birth, or about December 12 on the average. Bulls become common in the rookery area after the first week of December. The gestation period, then, probably does not exceed 10 months and 10 days, although it may be somewhat less.

ANALYSIS OF THE SKULL DATA

Seventy-three skulls of *Leptonychotes* have been studied, of which 67 were collected in the Bay of Whales in 1934. All of the latter were secured during the autumn months of February and March, except skulls of the season's young, taken from October onward, one July adult, and one December adolescent. When arranged in order of size, the autumn skulls, therefore, might be expected to show several marked discontinuities between the several age groups of adolescent and pre-adolescent seals.

Of four skull dimensions measured in this series, frequency distributions of the two most significant are given in Tables I and II. For many of the first year skulls the age is known to the day. The figures in parentheses are estimates based on skull characters, nose-tail measurement, and date of collection.

A marked break occurs in both the length and width curves, falling at the same point in the series for both measurements. All skulls under 225 mm. long and 142 mm. wide are season's young whose nose-tail length did not exceed 74 inches. Fig. 1 shows a corresponding hiatus at the 75–76 inch interval, separating individuals less than 6 months old from those born one year before them. But between the latter and the third-year skulls no such clear separation is found. Growth in length has lessened in its rate, and individual variation contributed to the overlapping. It seems probable, however, that the second division between age groups falls in the 250 mm. rather than in the 260 mm. class. The 7 skulls of the former are distributed thus: 250, 250, 250, 252, 253, then 257 and 258 mm., followed by another continuous progression. The nose-tail length of a seal that contributed one of the 250 mm. skulls was 84 inches, which is the upper limit of the second year length group (fig. 2). Skull data furnished no evidence for setting off the third-year group from the fourth.

The degree of closure of the sutures offers another general criterion of age. At two months the components of the brain-case are still distinct, except the occipitalia, which coalesce very early. The parieto-occipital suture is beginning to close at this time, the bones becoming firmly sealed during the

first 6 months. Infrequently a conspicuous parietal foramen (10 by 4 mm.) persists throughout the second month. The second important suture to close is the parieto-squamosal, followed by the parieto-frontal, which remains conspicuous long after closing. In the fifteen-month skulls the parieto-squamosal usually is completely obliterated, with the parieto-frontal closed and sometimes almost disappearing. The basioccipito-basisphenoid suture usually remains well defined in the second-year skulls but is largely closed in

TABLE I

Distribution of condylo-premaxillary lengths of 59 skulls. Class interval 10 mm.

Length in mm...	170–179	180	190	200	210	220	230	240	250	260	270	280	290
No. skulls.....	1	4	2	6	5	2	0	2	7	10	12	7	1
Age.....	4 da.	1–10 da.	10 da.	16–45 da.	43–(60) da.	(60–140) da.		(15–29) mo.	(27 months upward)				

TABLE II

Distribution of zygomatic widths of 71 skulls. Class interval 5 mm.

110–114	115	120	125	130	135	140	145	150	155	160	165	170	175	180
1	5	3	3	3	4	2	3	8	5	5	12	8	7	2

TABLE III

Age and Sex Differences in Mean Width-length Index of Skulls

NO. OF INDIVIDUALS	GROUP	MEAN INDEX	DIFFERENCE
56	Both sexes, all ages	61.5	
20	Season's young, both sexes	62.25 ± .27	1.12 ± .33
36	Adults and adolescents, both sexes	61.13 ± .20	
16	Males, all ages	62.62 ± .31	1.71 ± .400
21	Females, all ages	60.64 ± .25	
6	Males, adult and adolescent	62.47 ± .33	1.99 ± .44
15	Females, adult and adolescent	60.48 ± .29	

the third-year. This probably is the best skull character for separating these age groups. Its closure begins medially, the lateral arms sometimes remaining open after complete obliteration in the center.

The last sutures lost in the adult skull are the intermaxillary, interpalatine, and maxillo-palatines. This seems to furnish a much better indication of the age of adults than the skull length. Only one skull (282 mm.) shows closure of all three sutures, while in the two longest skulls (298 mm.) only the intermaxillary is effaced. Whereas 4 skulls of the 270 mm. and 4 of the 280 mm. classes showed no fusion across these sutures, 2 of the 260 (268 and

269 mm.), 3 of the 270, and 4 of the 280 mm. classes showed intermaxillary fusion. One in the latter class and one 279 mm. skull combined intermaxillary and interpalatine fusion only, while one 275 mm. skull had closed along the intermaxillary and maxillo-palatine sutures. It seems, then, that there is little correlation between skull size and the fusion of these elements, and that fully adult skulls may be at least as small as 268 mm. in length.

Increase in length throughout the series is paralleled only very roughly by increase in zygomatic width. In an effort to learn the cause of this irregularity, the ratio of width to length was expressed, for skulls furnishing both measurements, by the index: $\frac{\text{maximum zygomatic width}}{\text{condylo-premaxillary length}} \times 100$. The mean indices found for various groups are shown by Table III.

The difference between the skull index of young of the season and that of seals one year or more of age is 3.4 times its probable error. Of the sexed skulls the difference between the males and females, regardless of age, is 6.3 times its probable error. Of the skulls one or more years of age, the difference between males and females is 4.5 times its probable error. It therefore appears that all of these differences may be significant, particularly the sex differences, and that the skulls of males on the average are wider in proportion to length than those of females, and skulls of young of the year, wider than those of older seals.

THE ROOKERIES

At the latitude of the Bay of Whales the sun is not to be seen for 4 months of winter, reappearing on August 22. Although in rare cases seals were found upon the ice during the dark months, they do not venture from the water in any numbers until October. Siple found the first seal of the 1929 spring on August 19, but in 1934 we saw none until September 30, in spite of numerous trips about the bay, and observations by the autogiro pilot. The mean temperatures of August, September, and October, 1934, were −38.4°, −33.8°, and −15.6°F., respectively. These are official figures recorded at the base camp by W. C. Haines and G. Grimminger of the U. S. Weather Bureau.

The first seals to appear are pregnant females, which congregate along lines of weakness in the eight-foot layer of winter's sea-ice. Here they secure and maintain access to the sea through pressure cracks by sawing out the thinner new ice with their teeth. As described by Wilson (1907, p. 22), "The seal, fixing the canines and incisors of his lower jaw in the solid ice, begins to revolve the upper jaw about them, in this way using the teeth of the lower jaw as the fixed point of a centre-bit while those of the upper act as the cutting edge." We frequently watched seals at work, but this method was not seen. Swinging the entire head from side to side with the mouth held open at an angle of about 150°, they cut a double groove by use of the

canines (and perhaps incisors also) of both jaws. In one case a seal in the water rasped away the margin of the exit-hole with the upper teeth alone, without those of the lower jaw touching the ice.

Springtime concentrations of nearly all breeding females result in 4 large rookeries in the bay. Although a few scattered females bear their young along tidal cracks near the bay's mouth, the northernmost rookery is 8 miles from open water, at the southern limit of new ice where it meets the outer face of the tumultuous pressure ice of bygone years. Being less than two miles from our base and containing 50 mother-young pairs, this rookery was chosen for detailed study. A 9- by 12-foot tent was pitched at its edge for working and living quarters. Two miles to the southwest, a site hidden in the pressure ice sheltered 24 pairs. Three and 4 miles farther south, near the site of Amundsen's 1912 base, were two rookeries on the open sea-ice along a permanent pressure fault, where about 80 pups were born.

Several methods of marking seals were tried without success until branding was adopted, using a set of irons fashioned by Dr. Poulter. A five-foot wooden handle held a T-shaped iron holder containing three rectangular sockets. Into each socket was placed a number made of quarter-inch square iron rod. It was held firm by a bolt and could be removed by means of pliers. Each figure measured 3.5 by 2 inches. These irons were heated over a Van Prague pressure stove burning Stoddard's solvent. A surrounding section of large stove-pipe was necessary except on very calm days. For a mother and her young the same figures were used, but in reverse order, the greater number for the adult. Young were not branded until shortly before completion of the post natal moult. When possible the brand was placed dorsally, a foot or two in front of the tail. The number first was clipped into the wool with shears. This marking system made it possible to follow individually the activities of 243 Weddell seals until our departure in February. If seen again, these branded seals may throw light on their length of life and possible wanderings from the bay. The list of numbers used, and other data taken at the time of branding, has been deposited in the American Museum of Natural History, where it will be available to future Antarctic travelers.

BIRTH

The females spend much time sleeping on the ice during the week before the pups are born. Matthews (1929) reported that at South Georgia (lat. 54° S.), the northern limit of their breeding range, the pups are born in January. This seems remarkable in the light of the records below. At the South Orkneys, according to Brown (1908, p. 40; 1915, p. 189), birth occurs in the last days of August. Coming to the Antarctic Continent, the first young at Cape Adare (lat. 71° 30′ S.) were seen by the "Southern Cross" party early in September. In the rookery at 77° 50′ S., which Wilson (1907, p. 17) observed during two seasons, the earliest birth was on October 22. The

first in the Bay of Whales for two seasons was October 5, followed a full week later by another.

A pup may be 56 inches long from nose to tail at birth. They are born with eyes open. Except in rare cases a female produces only one pup a season. One pair of fraternal twins was seen in 1929, and another in 1934, but all 4 were dead when found and probably had been born so. These pups weighed about 50 pounds each. A female collected in the fall contained two small embryos, both in the same horn of the uterus. The umbilical cord is not bitten through by the female, but evidently has a weak spot where it is broken by the young or by the mother in moving about. The break occurs 3 or 4 inches from the umbilicus, and the pup carries the conspicuous stump for from 5 to 11 days before it drops off. The young at birth weighed from 50 to 78 pounds. The mean weight of 17 pups on the day of birth was 64.1 ± 1.84 pounds.

INCREASE IN WEIGHT

From October 15 to December 14, 1934, a study was made of the weight increases of 18 young, 12 of which were males. Weight readings were taken

TABLE IV

Mean Weekly Gain for the First Six Weeks, in Pounds

	WEEKS					
	I	II	III	IV	V	VI
Males	24.7	36.9	35.4	31.5	33.1	24.1
Females	32.1	38.6	37.4	28.5	26.1	20.5
Both	28.4	37.4	35.9	30.5	30.6	22.7

throughout this period at intervals averaging oftener than every third day. The seal was suspended in a rope net from spring scales supported by a portable tripod of twelve-foot bamboo poles. The results are summarized in Table IV, which shows the mean gain in pounds for each of the first 6 weeks. These figures have been computed by calculating the average daily gain from one weighing to the next, and filling with this value the daily interval or intervals between the two successive weighings. This interpolation method has been tested by applying to the actual weight readings, when applicable, a sliding seven-day interval with its position not fixed by date of birth. The results for 56 such recorded gains during seven-day periods are quite comparable to figures secured by interpolating average daily rates of gain. The maximum recorded seven-day gains for 9 individuals follow: 35, 40, 40, 45, 46, 48, 49, 49, and 50 pounds. Thus several seals averaged 7 pounds actual daily gain for 7 consecutive days or longer.

Weight readings were taken for each individual as long as it could be found

in the rookery. During the seventh, eighth, and ninth weeks the pups that remained spent much time in the water. Consequently, the readings after the sixth week usually were too scattered to form a valid basis for interpolation, and have not been used in Table IV. At about the seventh week the rate of gain diminishes rapidly until there is a cessation of weight increase, and a pronounced loss occurs. For example, a seal that weighed 300 pounds at 52 days of age, lost 17 pounds in the next 7 days. One weighing 245 at 42 days of age had lost 20 pounds 12 days later, and another weighing 283 pounds at 36 days, weighed 245 pounds at 59 days. This reversal in weight change is correlated with the beginning of nutritional independence. It was not possible to follow any of the young sufficiently long to determine how soon the loss in weight was regained.

DEVELOPMENT OF DENTITION

The growth changes in the dentition of 27 living young were studied. The dental formula for the species is:

$$\mathrm{I}\frac{2-2}{2-2}\ \mathrm{C}\frac{1-1}{1-1}\ \mathrm{PC}\frac{5-5}{5-5}=32$$

Usually the four canines pierce the gums before birth, and sometimes also the two outer incisors of one or both jaws. Typically the first incisors to appear were the outer ones of the upper jaw at 0–2 days of age, followed by the outer ones of the lower jaw at 2–6 days. In only 4 individuals did incisors (outer) show first in the lower jaw, and in two other cases the outer incisors of both jaws came at the same time. In one pup the inner incisors were first in the upper and the outers first in the lower jaw. Never were all four upper incisors to be seen until the outer incisors of the lower jaw had been cut; and never all four lower incisors until all four uppers had appeared, since the inner incisors of the upper jaw preceded those of the lower. On the average all eight incisors had appeared by 9 days, although sometimes as early as 2 or as late as 24 days.

The post-canine teeth show more variation in the order of appearance. Two young displayed these teeth in the upper jaw first, and another had them simultaneously in both. In the remaining pups the first cheek teeth appeared in the lower jaw at 0–8 days, averaging 4.2 days. In half the cases the fifth alone was the first pair to be cut, in the rest the second pair alone or combined with either the first, third, or fifth. In the upper jaw likewise the fifth pair preceded all others in slightly over half of the seals, and those remaining showed the fourth alone and fourth-fifth together as equally common, while each of four other combinations occurred first in only one pup. The first appearance of a post-canine in the upper jaw was in 0–22 days, averaging 7 days. The typical formula at the end of the first week, therefore, is:

$$I\ \frac{2-2}{\text{outer pair only}}\ C\ \frac{1-1}{1-1}\ PC\ \frac{5\text{th pair}}{5\text{th pair}}$$

The full set of teeth in the lower jaw comes well in advance of completion of the set in the upper. The last of all teeth to appear are, with few exceptions, the first or second pair of post-canines in the upper jaw. One individual had a complete set of teeth at 16 days. The set of another was still incomplete at 50 days, but since the missing pair was the fifth (ordinarily the first cheek teeth to appear), perhaps these were not destined to develop in this seal. The average age for attaining a complete dentition is 34 days. Evidence of loss or replacement of the first set of teeth by a second was found neither in living seals nor in the skull series.

NURSING AND WEANING

After the birth of its young the female does not enter the water for a week or more; hence she obtains no food. The production of milk in sufficient quantity for the young to gain weight at the rate of seven pounds daily demands utilization of much of the blubber stored beneath the skin. Even after the female starts feeding once more the blubber supply still is drawn upon, for the nursing female becomes visibly thinner each week.

The heaviest Weddell seal on record, a female, weighed 920 pounds (Bruce, 1915, p. 169). A mid-winter female collected in July, 1934, in the Bay of Whales, was estimated to weigh 900 pounds. It had a layer of blubber 4 inches thick. The skin and blubber together weighed 305 pounds, and in the rough-blubbering process 241 pounds were removed from the skin. In addition an estimated 75 pounds had been left on the carcass. It is very probable that the blubber constituted well over one-third the total weight of this 110-inch seal. Yet the skin and blubber of a 112-inch female taken in December just after rearing its young weighed only 170 pounds, or 55 per cent of that of the July female. Although longer than either the latter or Bruce's 920 pound specimen, the December seal's total weight was only 597 pounds.

The mean age of 13 young when last observed suckling was 45.2 days. Five of these were seen nursing at from 50 to 55 days of age. The age of permanent separation of 18 young from their mothers averaged 50.3 days, which probably is more nearly the correct average age for weaning also. A marked loss of weight by the young occurs about this time. The change from a milk diet is gradual, combining amphipod and isopod crustaceans with the milk for a time. The stomach of a 55 day seal contained milk and a few *Euphausia superba* and other crustaceans. Another pup taken December 24, hence about 2 months old, was filled with *Euphausia*, with a few fish eyes also, but no milk. Fish is the usual adult food, but crustaceans are much more easily caught by the young.

The method of nursing has been discussed by Wilson (1907, p. 18).

THE FIRST MOULT

The moult from the natal wool in 22 individuals of known age began at from 9 days (in 5 cases) to 21 days of age, averaging 13.8 days. In one case the moult lasted only 18 days; in another it was not yet completed after 51 days duration when the pup was 70 days old. The average duration of the moult is 30.2 days, so that at 44 days the average pup has replaced its woolly fur with a velvety black and white coat of short hair identical with that of a freshly moulted adult (Wilson, 1907, p. 25).

The moult is here considered to begin with the shedding of hair from the area where the first bare spot begins in the natal coat. In some individuals, however, there was noted a distinct general loosening of the hairs all over the body well before the onset of the general moult, so that hairs easily were dislodged when handling the animal, although not in an amount comparable to the loss occurring during the moult proper.

The precise sequence of the first moult is quite varied, as is the rate of its progress in different individuals. The following generalized description is based on detailed notes on the moult of 20 young.

The region where the wool first falls, exposing the short new hair, is about the umbilicus and genital orifice. This is accompanied or followed shortly by moulting about the eyes, corners of the mouth, and perhaps the chin. The next areas affected, on the third or fourth day of the moult, are the webs of the hind flippers above and below, the lower surface of the front flippers, a small area on the upper edge of each front flipper midway to the end, on the body before and sometimes behind the base of each front flipper, a patch on the nape, perhaps another on top of the head, and scattered spots on the shoulders. While these areas increase in size, others appear on the back, throat, axilla, upper and lower side of the shanks, two outer digits of the hind flippers, and on the upper and lower surface of the tail, leaving a fringe of wool around its edge. The pup remains in this patchy stage of the moult for one or two weeks.

At the middle of the moulting period, the average pup shows the front flipper moulted, except perhaps for its rear edge, and the hind one moulted except for narrow streaks of wool along the three inner digits and a very characteristic streak down the outer side of the shank. The head, a collar all around the neck, and the entire chest are moulted, the latter area narrowing into a mid-ventral strip about 8 inches wide that extends to the tail. The dorsal side still is predominantly woolly, but starting to moult in isolated streaks and patches about the scapulae and lower rump. Loss of the remaining wool from the dorsal parts and the flippers, and spreading of the ventral moult laterally, leaves only a slowly narrowing and thinning streak of wool along the sides as the typical final stage.

The moult of adult and adolescent Weddell seals takes place chiefly in

December and January. The first area to moult may be either a mid-ventral or mid-dorsal strip, the other following after, so that the sides are the last parts to change. In contrast to the first, the succeeding moults are not characterized by small isolated areas of new hair.

SWIMMING

Young Weddell seals do not postpone entering the water until after completing the moult, but are to be found swimming at frequent intervals throughout this period. In fact, two pups took to the water at 8 and 9 days of age, before the moult had begun. One was observed swimming at 10 days, another at 14, four at 16, and seven more before 20 days.

The first swimming is done in a shallow pool where lateral pressure has forced an ice syncline below sea level. The mother breaks the new ice and nuzzles the hesitant pup into the water, where from the first it seems quite adept in surface swimming. It can float with its nose above the surface even when apparently it is perfectly motionless. Occasionally the female supports it with her body, more from playfulness than necessity. Often she pushes its head under, although the pup frequently submerges of its own accord. Some days later the pair enjoy rolling and tumbling about together in the deep water holes. At about 25 days the pup may swim alone between holes. One was followed for 50 yards by its bleating calls while it swam under the ice at about 5 miles per hour, probably following a vein of air where the lower surface of an ice ridge was thrust above the water level. A pup at 34 days still hesitated to enter the water, although it had been seen swimming 12 days previously. After it had tentatively thrust in its head several times, the adult tugged it in by the scruff of the neck.

A 48 day pup fully visible in open water kept submerged for a maximum duration of 167 seconds.

MORTALITY

No natural enemies threaten this species in the Bay of Whales, where the fast ice offers protection from the killer whale. It is significant that no Weddell seals were found with the scars and wounds characteristically inflicted by these cetaceans, commonly to be seen on the crab-eater seals during their summer sojourn in the bay. Various causes contribute to the mortality of the young. Two pairs of twins did not survive birth. Another frozen and flattened pup was found with its viscera protruding through the ruptured abdominal wall, probably from the mother rolling upon it. When a young one dies on the ice the bereaved female mopes about the carcass for several days. A youngster fell into a crack and disappeared; its mother remained despondently with her head over the spot long after heavy ice had formed there. The females seem to suffer considerably in such cases, and they sometimes attempt to give suck to dead pups. Another young one

had died when almost out of the water hole, having been caught by its own weight in a small V-shaped gap between ice blocks. The extreme flexibility characteristic of a seal's thoracic wall had caused it to be suffocated.

In one case a pup had swum to an isolated hole in the pressure ice and never was located by the parent. The hole froze over and starvation was inevitable. In 1929, Siple recorded the permanent abandonment of an underweight (50 pound) young one at birth, and he estimated the pup mortality at 10 per cent. Six cases of disappearance of branded young with continued presence of the mothers bring the 1934 mortality in one rookery to at least 18 per cent. Four of these six were less than 20 days old, and probably they were drowned beneath the ice through inability to find a blow hole.

No dead adults were found, although several bulls evidently were bleeding to death from fights with other seals, and were scarcely able to move.

FIGHTING AMONG ADULTS

Fights are not strictly confined to the mating season, for freshly wounded bulls were seen as early as October 15. The few males appearing in the rookery during this month and in November were either wounded or were very old individuals. No real fighting actually was seen; it probably occurs in the water, for the bulls emerge seemingly only to sleep on the ice. The injuries are inflicted chiefly about the genital orifice, head, and neck, and are readily distinguishable from the long, deep gashes on the crab-eater seal caused by *Orca*. The cuts dealt by other seals are a few inches long. They suppurate freely and heal slowly. The skin of an aged bull presents a veritable network of black scars.

Fighting is not a prerogative of the males only. Two females were seen to rear up and snap at each other's heads a few times, when one of them showed interest in another's pup. In December, two females were found on the ice a few yards apart, both bleeding badly as though from a recent fight. The eye of another had been put out. An old female bore on one side of the neck a circular wound an inch deep and five inches across. One was wounded about the genital region, others on the breast, belly, or side. Possibly some such injuries are due to sharp edges of ice. The number of wounds and scars on the females is very small in comparison with those on males.

LOCAL DISTRIBUTION AND MOVEMENTS

During October and November, 1934, 243 Weddell seals were branded with individual numbers. Of the 83 pairs of mothers and young branded, 54 mothers and 48 young constituted "returns." These 102 seals furnished 1012 distinct records. Also 34 single adults furnished 161 additional return records. Detailed distribution records were obtained in the rookery and its environs at intervals averaging every 2.4 days throughout November and

December, and occasionally in January. From the resulting data the following summary has been prepared.

The first observed separation of mother and young occurred in 7 of the pairs from 7 to 15 days after birth, in 6 others from 16 to 20 days. The mother entered the water to feed at these times, if not before. Final separation for 18 pairs came at the average age of 50.3 days, the earliest being 40 days and the latest 55 days.

In the rookery region a force resulting from advance of the Barrier ice sheet from the southwest is opposed by the grounded Barrier at the eastern edge of the bay. Consequently, the bay ice, which reaches a thickness of 8 feet in one winter, is thrown into an undulating series of ridges and troughs. Ultimately a fault appears along the axis of each syncline and anticline, and the great blocks are upheaved to form the characteristic pressure ice. By the beginning of the pupping season, some of the synclines have been thrust below sea level and have cracked, so that elongated pools of salt water are produced. The latter freeze over at once, but not thickly enough to inconvenience the seals, which find their way up through the original crack, through the 10 feet or so of the pool above, and emerge from water holes which they maintain through the relatively thin surface ice. This accessibility to the sea, and hence to the food supply, explains the choice of the rookery site, at the southernmost edge of the winter's sea ice.

Each pool in the rookery was the focal point for a group of mother-young pairs. The pools averaged 180 yards apart, and the pairs occasionally moved from one to another, largely by water after the second week. The following table gives the mean weekly distance per pup, based on 38 of known age.

Weeks.....	I	II	III	IV	V	VI	VII	VIII	IX
Yards.....	74	267	288	255	329	418	523	207	650

The figures for the eighth and ninth weeks are much too small, for many of the young had left the rookery by this time and their more extensive wanderings elsewhere are not included. Throughout their first week, about three-fourths of the pups remained at the same pool, in the second, just half of them did so all week, and less than a third of them remained the third week. The maximum distance traveled by a pup in its first week was 800 yards, in the second week one went 1200, and one in its third week, 1500 yards. One pair remained at their original pool for a full 7 weeks, however, another for over 5, and 2 for 3 weeks.

In addition to the development of the young, the increasing warmth accompanying the advance of spring is an important factor favoring movement, since water holes are much more open in November than during October. The mean temperature for October is −15.6° F. with an average daily

maximum of −6.0°; for November these figures are −3.2° and +4.6°, and for December +16.4° and +24.0°F.

On only 18 occasions during October and November were bulls found in the rookery. Our trips to the Ross Sea at the mouth of the bay showed that during the pupping season the bulls frequent the vicinity of open water 8 miles north of the nearest rookery. Here at the base of the Barrier cliff at West Cape, an area 40 yards square accommodated 29 bulls and 18 non-pregnant and largely yearling females. Other groups near open water showed a similar ratio, and included neither pregnant seals nor pups.

During the first days of November, extensive pressure pools were formed along the Barrier's foot one mile east of the rookery. A group of over 50 adult females took up residence about these pools. All were then unbranded except 6 whose pups had died in the rookery. Probably many of the newcomers likewise were unsuccessful mothers from other rookeries in the bay. From the middle of November to January 1, their leisurely wanderings between pools along a 1.5 mile front totaled only from 2 to 10.5 miles each.

More extensive travels were undertaken by seals in other parts of the bay. The following table records the linear distances for those adults that went farthest, with the observed time interval. Sixteen of these were females, 11 of which had borne pups that spring.

Miles.....	4	4.5	5.5	5.7	6	6	6	6	6	6	6.5	7	7	9	11	12	12	12	12
Days.....	31	56	61	49	4	17	24	40	46	47	56	25	47	37	47	42	42	42	48

After the first week in December the bulls became common in the rookery area, these vigorous ones being in contrast to the few battered and senile males that had sought sanctuary there infrequently during the previous two months.

The mothers abandon their young during the first half of December, and mating probably occurs at this time.

During seismic sounding journeys and flights, Dr. Poulter noted seals in the few inlets along a hundred mile front of the Barrier cliff bounding the Ross Sea on the south. At Discovery Inlet, 50 miles west of the Bay of Whales, about 500 Weddell seals were seen at one time. About 50 were observed in a small bight 30 miles west of our base, and at Kainan Bay, 24 miles to the east of us, seals were reported by the aviators. They occupy, then, the only places along 100 miles of vertical sea-washed ice cliff where indentations allow sea-ice to remain fast. The southernmost recorded mammals are the Weddell seals seen in the southern arm of the Bay of Whales, 30 miles from open water at Lat. 79°S.

OCCURRENCE IN WINTER

During two winters at McMurdo Sound, Wilson (1907, p. 14) found Weddell seals quite in evidence throughout the winter night. In the Bay of

Whales, Amundsen's and the first Byrd expeditions had not found them at that season, the heavily drifted pressure areas being much less favorable for observations than the flat sea ice at Captain Scott's base. In 1929, however, Siple believed from the apparent age of the arched-over blow holes he found in early spring that these animals had wintered in the bay.

By March 15, 1934, seals had become difficult to locate, even from the air. They had retreated beneath the bay ice, for when holes were chopped through its two-foot thickness, seals at once thrust out their heads. By the middle of April it was impossible to find any on the ice. The sun set for the winter on April 19.

Two individuals were seen in chopped holes on May 15, and seals unmistakably were heard calling during both May and June, as they swam under our feet. The calls given under water are of the types which are produced with the mouth closed; we often watched seals on the ice while they uttered the same sounds. One type is a series of deep guttural thumps, beginning rapidly but with gradually increasing intervals as it continues. Another consists of a succession of very bird-like chirping notes, also diminishing in tempo. Other calls, given above the ice with the mouth open, are loud bellowings, roars, and moans, soft gurgling and grunting noises, and a staccato clicking together of the teeth. The pups give loud bleating and bawling cries. Sound records of the various calls were made.

In the last week of June, Siple led the four-man Marie Byrd Land party on a winter journey of four days to the open water at the mouth of the bay. This yielded the negative evidence that no seals were to be found along the northern edge of the bay ice at that time. We heard seals calling at the rookery site during the absence of the winter party, indicating that ice conditions in the area of pressure there probably favor the formation of cracks, invisible from the surface, where seals may find access to air beneath the snow drifts.

On July 26, a large female was collected at the rookery site. It contained a 45 pound embryo, and had come out upon the ice during a period of unusually mild weather. This midwinter seal was one of only two seals found in the Bay of Whales with mineral matter in the stomach. The mean daily temperature had increased from −46°F. to −6°F. in two days, and the following day, July 26, it was +8°F.

After the return of the sun on August 22, only a few recently used blowholes indicated the presence of seals. The new bay ice had reached approximately its maximum thickness, and although frequent autogiro flights were made over the bay throughout September, the pilot located no seals. The next one appeared above the ice on the last day of September.

It has been seen that seals are present in the Bay of Whales in every month of the year. It seems that their scarcity in winter is more apparent than real, and should be attributed to a change in habits in consequence of the increased difficulty of reaching the surface of the ice, and to the comfort-

ably uniform temperature of the water in contrast to the severe temperatures and wind conditions above. There is no evidence for believing that the species performs any general migration from the bay at any season.

The question of food might seem a serious one, but that it is met very successfully is evidenced by the remarkable amount of blubber stored during the winter. The stomach of the July seal was gorged with the fish *Pleurogramma antarctica*. How the Weddell seal is able to capture fish in the submarine darkness of the polar night is a problem regarding which only speculative suggestions could be offered.

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VARIATIONS IN TOWNSEND POCKET GOPHERS

By William B. Davis

The large Townsend pocket gopher now is restricted to the Great Basin where it occurs in widely separated localities. A discontinuous distribution such as this suggests, for one thing, that these isolated colonies are relics of a once nearly continuous distribution. If it existed at an earlier time in about the same general area that it now occupies, as is indicated by remains of pocket gophers related to *Thomomys townsendii* known from Pleistocene deposits at Fossil Lake, Oregon (see *Thomomys vetus* of present paper), and at American Falls, Idaho (Gazin, 1935), an explanation for its present distribution and differentiation is at hand.

These gophers are restricted by habitat preference to areas of fluviatile and lacustrine deposits where the soil is deep and relatively moist. Many localities at which they occur are separated one from the other by barriers of unfavorable soil. During the Pleistocene, when lakes Idaho, Lahonton, and Bonneville covered most of the present range of this species, however, climatic conditions in the Great Basin were markedly different from what they are today. Throughout a portion of this period these animals probably enjoyed a continous range over a considerable portion of that general region. Subsequent changes, especially diminished precipitation and the consequent reduction or complete disappearance of the lakes, are thought to have broken up their former range. As the waters receded and the deserts encroached upon territory formerly occupied, the gophers moved toward the lakes and streams. This hypothesis explains the present distribution of *T. townsendii* in western Idaho, Oregon, California, and Nevada.

The extent to which the Pleistocene Lake Bonneville affected the dispersal of this species in the eastern portion of its range is not clearly demonstrated because of the lack of fossil and Recent material from Utah. The close similarity in several structural features of the gophers from near Pocatello, Idaho, to those from northeastern Nevada, however, suggests that the ancestral stock of the population at the former locality migrated along the northern shore of Lake Bonneville and its outlet through Red Rock Pass to the Snake River. Certain physical and biotic barriers, as noted in the account of *T. t. similis* below, seem to have prevented a migration from Oregon eastward along the Snake River.

Bailey (1915), I think correctly, regarded *Thomomys bottae* of current terminology as the nearest relative of *townsendii*. Of all the *townsendii* group, *nevadensis* seems to be structurally most like *bottae*. *Thomomys bottae* and *T. townsendii*, however, appear to be distinct species; at any rate I know of no intergradation or hybridization between the two.

In this study of *townsendii*, greater weight has everywhere been accorded cranial characters than those of color, although in certain populations where

Average and extreme measurements, in millimeters, of adults in seven races of Thomomys townsendii

RACE	NUMBER OF SPECIMENS	TOTAL LENGTH	LENGTH OF TAIL	LENGTH OF HIND FOOT	BASILAR LENGTH OF HENSEL	ZYGOMATIC BREADTH	LEAST INTERORBITAL CONSTRICTION	MASTOIDAL BREADTH	LENGTH OF NASALS	BREADTH OF ROSTRUM	LENGTH OF ROSTRUM	ALVEOLAR LENGTH OF MAXILLARY TOOTH ROW	PALATO-FRONTAL DEPTH
Townsendii	4 ♀	276 260–288	90 84–98	37 35–41	42.9 40.8–43.5	31.6 29.8–32.8	7.5 7.3–7.7	26.0 24.2–26.6	17.2 15.9–18.2	9.6 9.0–9.8	19.9 18.7–20.4	10.1 9.4–11.0	19.0 18.0–19.6
Owyhensis	4 ♀	248 230–255	74 70–77	33 33–33	37.6 36.7–38.7	27.8 27.1–28.5	7.5 7.2–7.8	22.3 21.9–22.9	14.6 14.0–14.9	8.3 8.2–8.5	17.5 17.1–17.8	9.5 9.3–9.7	16.6 16.1–17.5
Similis	5 ♀	241 230–260	68 60–83	33 32–35	39.2 38.1–41.0	28.5 27.8–29.9	7.6 7.3–8.1	23.1 22.4–24.5	15.2 14.4–16.4	9.0 8.5–9.6	18.1 17.1–19.0	9.8 9.6–9.9	17.2 16.6–18.3
Elkoensis	5 ♀	255 235–264	75 70–81	36.5 36–37	41.3 40.9–41.7	30.4 29.2–31.5	7.3 7.0–7.8	24.3 23.1–25.0	16.3 15.1–17.1	9.1 8.8–9.3	19.7 19.0–20.2	9.7 9.4–10.2	18.1 17.7–18.6
Bachmani	5 ♀	255 244–264	85 81–90	39 35–45	39.0 37.6–41.2	29.8 28.3–31.3	7.6 7.1–7.9	24.5 23.7–25.2	15.6 14.9–16.1	9.3 9.2–9.4	18.5 18.4–18.5	10.5 9.8–10.7	17.7 16.9–18.0
Nevadensis	5 ♀	235 232–244	57 53–60	34 33–35	38.0 37.0–38.5	28.2 27.0–29.3	6.7 6.4–7.2	23.5 23.0–24.2	13.9 13.7–14.0	8.8 8.7–9.1	17.6 17.2–17.7	10.2 9.5–10.3	17.0 16.4–17.5
Relictus	3 ♀	245 241–254	78 73–81	34 31–36	39.9 37.6–41.7	29.0 27.7–30.2	7.0 6.2–7.7	24.2 22.9–25.5	16.1 15.5–17.0	9.4 9.0–9.8	19.0 18.0–20.0	9.9 9.5–10.1	17.6 17.0–18.3
Townsendii	6 ♂	294 272–340	92 82–113	38 36–42	44.9 41.2–50.0	33.2 30.4–36.9	7.6 7.2–7.9	27.2 24.7–30.4	18.3 16.6–21.0	9.8 9.1–11.0	21.0 18.8–24.0	10.0 9.5–10.5	19.8 18.2–22.0
Owyhensis	4 ♂	274 265–293	88 77–94	37 35–40	43.8 42.8–44.3	31.9 31.9–32.1	7.4 7.0–7.9	26.2 25.4–26.8	18.1 17.4–19.1	9.9 9.5–10.1	21.3 20.5–21.8	10.0 9.7–10.2	19.1 18.2–19.8
Similis	5 ♂	283 263–305	84 80–90	38 37–40	46.1 45.0–47.7	33.9 32.2–34.6	7.4 7.1–7.7	27.7 26.5–29.2	19.6 19.0–20.2	10.5 10.2–11.0	22.8 22.0–23.4	10.9 10.7–11.0	20.5 19.7–20.6
Elkoensis	5 ♂	280 265–290	86 81–95	38 37–41	43.5 42.1–44.5	32.4 30.6–33.9	7.3 7.0–7.5	25.6 25.0–26.4	18.0 17.1–18.9	9.7 9.4–9.9	20.8 19.5–22.4	10.2 9.5–11.0	18.9 18.3–19.6
Bachmani	3 ♂	267 261–276	86 82–92	37 36–38	41.2 39.6–42.7	31.2 29.7–32.0	7.3 7.2–7.4	25.6 24.6–26.1	16.8 15.5–17.5	10.0 9.5–10.7	19.3 18.0–20.6	10.5 9.8–10.9	18.6 17.8–19.2
Nevadensis	5 ♂	262 251–269	69 66–73	37 36–38	41.1 39.6–42.9	30.6 29.0–32.4	7.0 6.4–7.4	25.5 24.6–26.5	15.6 14.4–16.9	9.4 9.0–9.6	19.7 18.7–20.3	10.3 9.9–10.5	18.4 17.5–19.1
Relictus	4 ♂	279 256–301	91 82–101	38 36–40	44.9 43.8–47.4	33.0 31.7–34.0	7.4 7.1–7.5	27.9 27.2–29.0	19.0 18.0–20.0	10.6 9.9–10.9	22.4 21.0–23.5	9.8 9.4–10.0	19.5 18.8–20.3

color is fairly constant, this has been given greater consideration than elsewhere. Also, I have followed Grinnell (1931) in placing greater reliance on cranial characters of females than on those of males. Diagnoses and descriptions which follow are based solely upon females, unless otherwise stated.

A critical analysis of 275 specimens of *T. townsendii* from California, Oregon, Idaho, and Nevada indicates the existence of two groups as judged by the width of the dorsal surface of the premaxillae. In all specimens examined from Nevada, California, and extreme southeastern Oregon, the width of the two premaxillae equals about two-thirds of the breadth of the rostrum. In the specimens from Idaho and northeastern Oregon, these same bones comprise about one-half the rostral breadth. Some specimens from the vicinity of Pocatello, Idaho, show a tendency toward a widening of the premaxillae and in this character approach specimens from near Elko, Nevado.

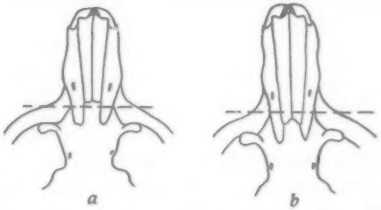

FIG. 1. Outline drawings, x1, of dorsal views of rostra, to illustrate relative length of nasals in *Thomomys townsendii*. a. *T. t. nevadensis*, no. 37,077, Mus. Vert. Zool., from type locality; b. *T. t. elkoensis*, no. 67,928, Mus. Vert. Zool., from Elburz, Nevada.

In the group with narrow rostra, 3 races are recognized; in the group with broad rostra, 4. In the latter, one race, *bachmani*, has a discontinuous range and each of the more or less isolated populations deviates from the mean, although to a lesser degree than the populations named on the periphery of the range. Considered in this way, the lower Humboldt River may be thought of as the area where intergradation occurs among members of the broad-rostrum group.

In the group with broad premaxillae, two races, *nevadensis* and *relictus*, have been recognized by C. Hart Merriam and J. Grinnell, respectively. Of these two, *nevadensis*, from the type locality in the upper Reese River Valley, 5 miles west of Austin, Nevada, is unique in that the nasals terminate anterior to the frontal tongues (an anterior projection of each frontal bone between the premaxillae and the maxillary base of the zygomatic arch) (fig. 1). In addition, the zygomatic arch is relatively weak, the anterior end of the jugal slightly expanded, and the sphenorbital fissure enlarged dorsally.

Thomomys townsendii relictus is easily distinguished from topotypes of *nevadensis*, but its relationship to that race can be traced through specimens

from northwestern Nevada. These specimens and those from southeastern Oregon, in which the rostrum and the premaxillae are broad, have been referred by Bailey (*op. cit.*, p. 45) to *nevadensis*. They differ from topotypes, however, as follows: Nasals actually and relatively longer; frontals (measured in median sagittal plane) considerably shorter than nasals; rostrum relatively broader; zygomatic arch heavier; anterior end of jugal enlarged; sphenorbital fissure smaller. Specimens from the Little Humboldt River drainage basin differ but little from those in the Quinn River basin, but those taken along the Humboldt River from Battle Mountain to Lovelock are nearly intermediate between *nevadensis* and the population at Quinn River. In comparison with the Quinn River specimens, Grinnell (1926) has pointed out that *relictus* has the premaxillary tongues much narrower; the brain case deeper and not so flattened; and the incisors more procumbent. Thus it appears that specimens from southeastern Oregon and northwestern Nevada are structurally, although not geographically, intermediate between *nevadensis* and *relictus*.

Although occupying a portion of the same hydrographic basin in which *nevadensis* is found, specimens from near Elko, and Pine Creek, Nevada, can be distinguished from topotypes. In contrast with typical *nevadensis*, these specimens have the anterior border of the alisphenoid so shaped that the root-capsule of the second upper molar is exposed to view. In addition, the nasals are longer and project posteriorly beyond the frontal tongues. Their dark coloration is fairly constant and unlike that found in other Nevada-taken specimens, but similar to that of specimens from near Pocatello, Idaho.

In the group with slender premaxillae, the subspecific name *townsendii* has been employed for specimens from southern Idaho and northeastern Oregon. Bailey (*op. cit.*, p. 43) had no specimens from south of the Snake River in Idaho. He did have specimens, however, from Oregon on the Great Basin side of the river opposite Payette, Idaho. The 15 specimens now available from Owyhee County, Idaho, south of the Snake River, although in general resembling typical *townsendii*, differ from it in many respects. Skulls of adult females are considerably smaller; nasals shorter; dorsal outline of maxillary arms of zygomatic arches flatter; hind foot smaller.

Specimens from both sides of the Snake River near Pocatello, Idaho, are structurally, although not geographically, intermediate in several cranial characters between typical *townsendii* and specimens from near Elko, Nevada. Although they apparently are related to the Nevadan population, they appear to be distinct. This colony now is completely isolated and fully 150 miles distant from any other race of the species.

To summarize: It appears that in the species *Thomomys townsendii*, 7 distinct major centers of differentiation can be recognized, the population in each of which is fairly homogeneous and distinct from any other. Of

these, 3 have previously been named. Descriptions are given of these, of the 4 Recent races here named as new, and of a newly named fossil species from the Pleistocene beds at Fossil Lake, Oregon.

Unless otherwise indicated, specimens are in the collection of the Museum of Vertebrate Zoology. Supplementary material has been made available by H. H. T. Jackson and A. H. Howell from the collections of the Bureau of Biological Survey; by George Cantwell from collections in the Los Angeles

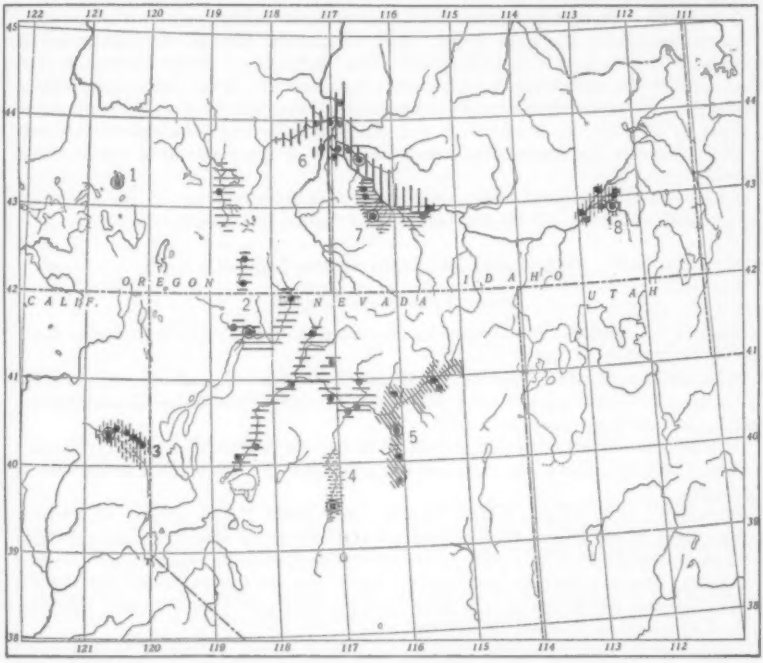

FIG. 2. Map showing known ranges of races of *Thomomys townsendii*; also the type locality of *Thomomys vetus*. Solid circles represent localities from which specimens have been examined or recorded; solid circle within a ring indicates type locality. 1, *Thomomys vetus;* 2, *Thomomys t. bachmani;* 3, *Thomomys t. relictus;* 4, *Thomomys t. nevadensis;* 5, *Thomomys t. elkoensis;* 6, *Thomomys t. townsendii;* 7, *Thomomys t. owyhensis;* 8, *Thomomys t. similis.*

Museum; by C. L. Camp from collections in the University of California Museum of Paleontology; and by Ralph Ellis, from his private collection. Grateful acknowledgment also is made to Professors J. Grinnell and E. Raymond Hall for critical assistance with the present study.

All capitalized color terms are after Ridgway, Color Standards and Color Nomenclature, 1912.

Thomomys townsendii nevadensis Merriam

Nevada Pocket Gopher

Original description.—*Thomomys nevadensis* Merriam, Proc. Biol. Soc. Washington, vol. 11, 1927, p. 213.

Type.—Male, young adult, skin and skull; no. $\frac{25001}{32413}$, Biol. Surv. coll.; Reese River, five miles west of Austin, Lander County, Nevada; collected November 11, 1890, by Vernon Bailey; original no. 2097.

Distribution.—Definitely known only from the type locality.

Characters.—Size: Medium. Color: Light Cinnamon Buff above, ligher below; upper surface of feet, tail, and chin white; nose sooty gray. Skull: Medium in size; premaxillae broad; nasals short, seldom reaching posteriorly to frontal tongues; sphenorbital fissure enlarged dorsally and exposed to view; root-capsule of second upper molar covered by alisphenoid; jugals short and weak, anterior edge of alisphenoid nearly vertical; interparietal trapezoidal; posterior angle of zygomatic arch less than 120 degrees.

Comparisons.—See *Comparisons* under accounts of other races.

Specimens examined.—Total number, 21, all from the type locality.

Thomomys townsendii relictus Grinnell

Honey Lake Pocket Gopher

Original description.—*Thomomys relictus* Grinnell, Univ. California Publ. Zool., vol. 30 (1), 1926, p. 2.

Type.—Male, old adult, skin and skull; no. 35271, Mus. Vert. Zool., valley of the Susan River two miles south of Susanville, Lassen County, California; collected June 5, 1925, by Joseph Dixon; original no. 8581.

Distribution.—So far as known, restricted to the bed of Honey Lake Valley, Lassen County, California, and to the main tributary valley of the Susan River as far west as Susanville.

Characters.—Size: Large. Color: Lighter than Buffy Brown above, Ochraceous Buff to Light Mouse Gray below; lateral lips and nose sooty black; chin white; upper surfaces of feet and all of tail white; postauricular patches sooty black. Skull: Large; premaxillae broad, attenuate posteriorly; nasals long, projecting posteriorly beyond frontal tongues; jugals heavy; occipital condyles relatively close together; posterior angle of zygomatic arch about 130 degrees.

Comparisons.—Compared with *nevadensis*: Nasals longer, extending to or beyond frontal tongues; sphenorbital fissure smaller; incisors wider; jugals heavier; occipital condyles closer together. Compared with *townsendii*: Premaxillae wider; occipital condyles closer together; interparietal rhomboidal, rather than triangular; anterior angle of zygomatic arch less acute.

Specimens examined.—Total number, 23, all from Lassen County, **California,** as follows: Gibson Ranch, 2 mi. E. Litchfield, 1; Amedee, 4; 4 mi. E.S.E. Amedee, 1; Honey Lake, 6 mi. N.W. Amedee, 3; 2–3 mi. S. Susanville, 8; 4.5 mi. E.N.E. Susanville, 6.

Thomomys townsendii bachmani, new subspecies

Bachman Pocket Gopher

Type.—Female, adult, skin and skull; no. 7855, Mus. Vert. Zool.; Quinn River Crossing, 4100 feet altitude, Humboldt County, Nevada; collected May 29, 1909, by Charles H. Richardson, Jr. and Walter P. Taylor; original no. 2704 of C. H. Richardson.

Distribution.—From northwestern Nevada in the Quinn River, Little Humboldt River, and lower Humboldt River valleys northward to Malheur Lake, Oregon.

Characters.—Size: Large. Color: Grayer than Buffy Brown above, Light Grayish Olive below; nose Mummy Brown; postauricular patches black; tail and upper surfaces of feet whitish; throat-patch white. Skull: Premaxillae broad; nasals long and extending to or beyond frontal tongues; sphenorbital fissure slightly expanded dorsally; root-capsule of second upper molar covered by alisphenoid; jugals heavy.

Comparisons.—A member of the broad premaxillae group. Compared with *nevadensis*: Nasals considerably longer and extending to or beyond frontal tongues; zygomatic arch heavier; sphenorbital fissure less expanded dorsally; alveolar length of maxillary tooth row greater. Compared with *relictus:* Premaxillary tongues broader; brain case shallower and more flattened; incisors more recurved; occipital condyles farther apart. Compared with *elkoensis:* Anterior edge of alisphenoid covering root-capsule of second upper molar; distal end of maxillary arm of zygomatic arch larger; rostrum less depressed.

Remarks.—Specimens from along the Humboldt River from Battle Mountain to Toulon are intermediate in many respects between *bachmani* and *nevadensis*. On the basis of length of nasals, however, they are referable to *bachmani*. Bailey (*op. cit.*, p. 45) records one specimen not examined by me from Alvord, Oregon. This locality falls within the range of *bachmani* as outlined above.

Specimens examined.—Total number, 83, as follows: **Nevada.** *Humboldt County:* 18 mi. W. Battle Mountain, 1 (Biol. Surv. coll.); McDermitt, 9 (Biol. Surv. coll.); Paradise, 8 (Biol. Surv. coll.); Big Creek Ranch, 3; 18 mi. N.E. Iron Point, 7; Quinn River Crossing, 14; 1 mi. N. Winnemucca, 5. *Lander County:* Argenta, 1 (Biol. Surv. coll.); Battle Mountain, 15 (Biol. Surv. coll.). *Pershing County:* Lovelock, 2; Toulon, 1. **Oregon.** *Harney County:* Lake Alvord, 8 (7 in Biol. Surv. coll.); Tum Tum Lake, 6 (Biol. Surv. coll.); 5 mi. S.W. Narrows, 3.

Thomomys townsendii elkoensis, new subspecies

Elko Pocket Gopher

Type.—Female, adult, skin and skull; no. 70583, Mus. Vert. Zool.; Evans, Eureka County, Nevada; collected May 30, 1936, by Ward C. Russell; original no. 4614.

Distribution.—So far as known, restricted to the upper portion of the Humboldt River drainage basin.

Characters.—Size: Large. Color: Darker than Sepia above, darker than Dark Mouse Gray below; nose sooty black; postauricular patches black; tail, upper surfaces of feet, and throat-patch white. Skull: Premaxillae broad, nasals long, extending posteriorly beyond frontal tongues; anterior face of alisphenoid curved posteriorly exposing root-capsule of second upper molar; sphenorbital fissure contracted dorsally.

Comparisons.—A member of the broad premaxillae group. Compared with *nevadensis:* Nasals extending posteriorly beyond frontal tongues, rather than terminating anteriorly thereto; anterior face of alisphenoid posterior, rather than anterior, to root-capsule of second upper molar; sphenorbital fissure contracted, rather than expanded, dorsally. Compared with *relictus:* Posterior extensions of premaxillae broad, rather than attenuate; anterior face of alisphenoid posterior, rather than anterior, to root-capsule of second upper molar; foramen magnum wider than high, rather than higher than wide. Compared with *bachmani:* See *Comparisons* under account of that race. Compared with *similis:* Premaxillae averaging wider; alveolar length of maxillary tooth row less; zygomatic arch weaker; jugals more attenuate anteriorly, that is, less expanded.

Specimens examined.—Total number, 25, from Nevada as follows: *Elko County:* 2–3 mi. W. Halleck, 5200 ft., 9 (8 in Ralph Ellis coll.); 3 mi. S. Halleck, 5200 ft., 7 (Ralph

Ellis coll.); 4 mi. W. Halleck, 1; Independence Valley, near Carlin, 1 (U. S. Nat. Mus.). *Eureka County:* Evans, 2; 4 mi. S. Romana, 3; Winzell, 2.

Thomomys townsendii townsendii (Bachman)

Townsend Pocket Gopher

Original description.—*Geomys townsendii* Bachman [from Richardson's MS] Jour. Acad. Nat. Sci. Philadelphia, 1839, vol. 8 (1), p. 105.

Type.—Skin and skull; no. 147, Academy Natural Sciences Philadelphia; near Nampa, Canyon County, Idaho; collected by J. K. Townsend.

Synonym.—*Thomomys nevadensis atrogriseus* Bailey, Proc. Biol. Soc. Washington, vol. 27, 1914, p. 118. Type locality, Nampa, Idaho.

Distribution.—From near King Hill, Elmore County, Idaho, west along north side of Snake River to Weiser and thence into valleys of the Malheur and Owyhee rivers of northeastern Oregon, and along south side of Snake River east as far as Homedale, Owyhee County, Idaho.

Characters.—Size: Large. Color: Typically darker than Sepia above, Light Cinnamon Buff below (melanistic individuals occasionally taken); nose sooty black; postauricular patches black; tail, upper surfaces of feet, chin, and lateral lips white. Skull: Large, angular; zygomatic arch heavy; premaxillae narrow; rostral pits absent; nasals long, extending posteriorly beyond frontal tongues; dentition heavy.

Comparisons.—See *Comparisons* under accounts of other races.

Remarks.—I have compared the skull of the type specimen of *T. townsendii* with that of an animal (of the race *similis*) of approximately the same age from near Fort Hall, Idaho, where Townsend spent some time in 1834. There is little doubt in my mind but that Townsend's specimen came from some locality outside the range of *similis*, because the type specimen has wider incisors, longer maxillary alveolus, and narrower premaxillae. These structural features are reproduced in sub-adult individuals of *T. t. townsendii* from near Nampa, the only other race whose range Townsend is known to have visited. Thus my independent investigation lends support to Bailey's designation (1915) of the type locality of *T. t. townsendii* as near Nampa, Canyon County, Idaho, although because of the immaturity of the type-specimen I hesitate to indicate definitely the place whence it came. The following are cranial measurements, in millimeters, of the type specimen: Basilar length of Hensel, 34.9; zygomatic breadth, 25.6; least interorbital breadth, 7.4; mastoidal breadth, 21.7; length of nasals, 13.0; breadth of rostrum, 8.1; length of rostrum, 15.4; alveolar length of maxillary tooth row, 9.5; palato-frontal depth, 15.0.

The range of *T. t. townsendii* is transected by the Snake River where it forms the boundary between Idaho and Oregon. Typical individuals of this race occur on the Great Basin side of the river at many localities in Oregon, but at only one (Homedale) in Idaho. From Murphy east along the south side of the river to Indian Cove, another race, *owyhensis*, is found, the range of which is separated from that of *townsendii* on the south side of the river by a northward projection of the plateau between Marsings and Murphy. Since the Snake River, along much of its course, now acts as an impassable barrier to populations of this genus, an explanation of the present occurrence of *T. t. townsendii* on both sides of the river naturally directs one's attention to conditions in the past.

In discussing the geology of this area, Hay (1927) suggested that at the beginning of the Tertiary the Snake River occupied a broad, deep valley and that at some later time, now supposed to be in the Eocene, the river became obstructed in western Idaho and eastern Oregon by flows of lava or by elevation of the land. One result was the formation of an immense lake which extended in a long curve eastward and northward

nearly to the location of the southward boundary of Yellowstone National Park. In time this lake became partially filled by deposits brought down from the surrounding mountains and by volcanic dust. The beds thus laid down constitute what is now known as the Payette formation. Remains of vertebrate animals have been found at many places in these sedimentary deposits. Cope gave to the more recent of these deposits the name "Idaho formation". Stratigraphically there appears to be no break in the sequence from the Payette formation to the Idaho. Because of the apparently unquestionable presence, in the Idaho beds, of *Equus*, *Camelops minidokae*, the genus *Cervus*, *Bison alleni*, and two species of elephants—*Elephas imperator* and *E. columbi*—Hay referred the formation to Lower Pleistocene.

In Late Pliocene and Early Pleistocene, this large lake in western Idaho probably extended south into Oregon nearly to the northern limits of Lake Lahonton and existed at about the same time as lakes Lahonton and Bonneville. If, and when, the Snake River was blocked, the shore lines of these several lakes and their contributary streams might have offered a means by which *Thomomys t. townsendii* could have migrated to the area now occupied by it in western Idaho. Subsequently, hundreds of feet of sediment were deposited in the lake bed, and, after the water rose to a certain level, drainage to the westward along the general course of the present river was re-established. The reformed river is thought thus to have separated the population of this race as we see it today. If this explanation of the separation into two portions of the single subspecies *T. t. townsendii* be accepted, we are led to the conclusion that the effects of isolation have been counteracted either by the homogeneity of the original population or by identical selective factors so that the now separated portions of the population, if they have changed at all, have undergone parallel evolutionary trends. As judged from a comparison of the crania of *T. t. townsendii* with the extinct *Thomomys vetus* from Fossil Lake, Oregon, the latter inference is more likely, because in all Pleistocene *Thomomys* from the Great Basin, the lingual faces of the cheek-teeth are more rounded than in their Recent representatives. This parallel evolution in the *quadratus*, *bottae*, and *townsendii* groups is interesting, but the point is that change probably *has* occurred, possibly in the line of *T. t. townsendii* as well as in other stocks.

Specimens from Hammett, Elmore County, are below the mean size of typical *townsendii* and resemble in external appearance specimens of *owyhensis* from Indian Cove south of the Snake River. Differences in cranial characters, however, indicate that no mingling of *owyhensis* and this northern population of *townsendii* has taken place here. The only visible barrier to prevent this is the river, which averages about 600 feet in width at this place.

The breeding habits of *townsendii* have been discussed in part by Horn (1923). Of 20 females collected in the vicinity of Vale, Oregon, from March 27 to April 1, 1921, 18 were pregnant and 9 of these showed signs of suckling an earlier litter. He concluded that each female of this race has at least two litters of young in close succession early in the season. None of the 16 females that I collected in Idaho from May 28 to August 30 was pregnant, but most of those taken in May and June showed evidence of having had young.

Records of occurrence.—Specimens examined, 87, as follows: **Idaho.** *Payette County:* 2 mi. S. Payette, between Payette and Snake Rivers, 4. *Canyon County:* Nampa, 2 (1 in Los Angeles Mus.); N. side Snake River, 4 mi. S. Wilder, 5. *Owyhee County:* Homedale, 3. *Elmore County:* Hammett, 9. Additional records (Bailey, 1915): *Washington County:* Weiser. *Canyon County:* Caldwell. **Oregon.** *Malheur County:* Ontario, 23 (21 in Biol. Surv. coll.); Owyhee, 6 (Biol. Surv. coll.); Vale, 35 (Biol. Surv. coll.).

Thomomys townsendii owyhensis, new subspecies

Owyhee Pocket Gopher

Type.—Female, adult, skin and skull; no. 67490, Mus. Vert. Zool.; Castle Creek, eight miles south of Oreana, Owyhee County, Idaho; collected May 22, 1935, by William B. Davis; original no. 1260.

Distribution.—Owyhee County, Idaho, south of the Snake River, from near Murphy east to Indian Cove.

Characters.—Size: Medium. Color: Lighter than Sepia above, lighter below; nose sooty black; upper surfaces of feet and tail white. Skull: Small for this species; premaxillae narrow; nasals short, extending to or beyond frontal tongues; maxillary arm of zygomatic arch short.

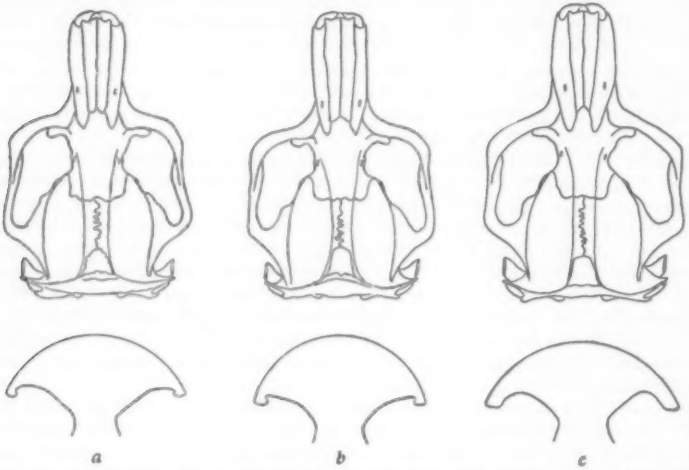

FIG. 3. Outline drawings, x1, of dorsal views of skulls, and outlines of maxillary plates of zygomatic arches when skulls are viewed from front, to illustrate variation in skulls of races of *Thomomys townsendii*. a. *T. t. owyhensis*, no. 72,002, Mus. Vert. Zool., from Indian Cove, Idaho; b. *T. t. townsendii*, no. 72,204, Mus. Vert. Zool., from Hammett, Idaho; c. *T. t. bachmani*, no. 7855, Mus. Vert. Zool., from Quinn River Crossing, Nevada.

Comparisons.—A member of the narrow premaxillae group. Compared with *townsendii:* Nasals actually and relatively shorter. Although skulls of *townsendii* from Hammett are similar in size to those of *owyhensis*, there is no overlap in length of nasals. Maxillary arm of zygoma shorter, causing a more flattened dorsal outline (fig. 3); squamosal arm of arch abruptly curved mediad leaving a wide space between arm and external auditory canal. Compared with *similis:* Smaller, nasals shorter; rostrum actually and relatively narrower. Differs from *bachmani*, *nevadensis*, *relictus*, and *elkoensis* chiefly in narrower premaxillae and absence of rostral pits.

Remarks.—This race of pocket gopher occurs chiefly in deep, clay-loam soils along water courses and in irrigated fields at lower elevations in northern Owyhee County. At higher elevations another species, *Thomomys quadratus*, is found. In Reynolds Creek Valley *owyhensis* does not occur, and here *quadratus* has extended its range north

to the Snake River, separating *owyhensis* and *townsendii*. Elsewhere these two are separated by the Snake River. Indian Cove marks the eastern limits of range of *owyhensis*.

Specimens from the eastern portions of the ranges of *townsendii* (Hammett) and *owyhensis* (Indian Cove) occupy similar types of soil and in external appearance the animals are indistinguishable. In cranial characters, however, they are distinct (fig. 3). Here only the Snake River separates the two populations, and its effectiveness as a barrier to pocket gophers is indicated by the differences observed in individuals from the two sides of the river.

Records of occurrence.—Specimens examined, 15, all from the south side of the Snake River in Owyhee County, Idaho, as follows: Castle Creek, 8 mi. S. Oreana, 6; Indian Cove, 2; 5 mi. S.E. Murphy, 6; Sinker Creek, 7 mi. S.E. Murphy, 1.

Thomomys townsendii similis, new subspecies

Bannock Pocket Gopher

Type.—Female, adult, skin and skull; no. 46507, Mus. Vert. Zool.; Pocatello, Bannock County, Idaho; collected November 10, 1928, by Wayne B. Whitlow; original no. 182.

Synonyms.—*Thomomys townsendii townsendii*, Bailey (1915); *Thomomys townsendii townsendii*, Whitlow and Hall (1933).

Distribution.—On both sides of the Snake River from American Falls northeast to Pingree, and east along the Portneuf River to Pocatello.

Characters.—Size: Medium. Color: Darker than Sepia above, darker than Dark Mouse Gray below; nose sooty black; postauricular patches black; tail bicolor, above mouse gray, below white; upper surfaces of feet and throat patch white. Skull: Premaxillae relatively broad; nasals long, extending posteriorly beyond frontal tongues; mastoid breadth averages 59 per cent of basilar length of Hensel.

Comparisons.—Compared with *townsendii:* Averages smaller; premaxillae average wider; skull smaller, mastoidal breadth actually and relatively less; hind foot averages 33 mm. as opposed to 37 mm. Compared with *owyhensis*: External proportions similar, but skull larger and averaging 30 per cent heavier by weight; incisors wider; zygomatic arch more obtusely angled both posteriorly and anteriorly. Differs from Nevada-taken specimens of this species in having narrower premaxillae and usually heavier zygomatic arches.

Remarks.—This race is restricted to the deep soils in the vicinity of the American Falls reservoir. West of the Snake River it formerly occupied only the river-bottom lands, but because of the construction of the American Falls dam and the subsequent impounding of water in the reservoir, it has migrated to higher lands in the narrow irrigated region from near American Falls north to near Moreland. The presence here of the animals on the two sides of the river in the upper part of its course is more easily understood than in the case of *T. t. townsendii*. They might cross by burrowing through the snow when it covers the frozen river. Or they might have crossed in summer when the river was very low. Within historic times the river in the vicinity of Blackfoot has been known to recede to such an extent that in places wagons could be driven across the channel on relatively dry ground. In recent years, however, water control activities have prevented the river from reaching its previous low levels.

Westward extension of the range of *similis* north of the Snake River is prevented by extensive lava fields and desert land which occur from the river, between Lake Walcott and American Falls, north to the Sawtooth Mountains. North and west of Blackfoot another species of pocket gopher, *Thomomys idahoensis*, is found. *Thomomys pygmaeus* and *T. quadratus* occupy the region north and east of Blackfoot, and *quadratus* occurs in the valley of the Portneuf River east of Pocatello, in the surrounding hills, and along

the south side of the Snake River from near American Falls west as far as Hagerman, and probably to near Indian Cove, the locality marking the eastern limits of *T. t. owyhensis*. Thus, *similis* is hemmed in on all sides either by other species of pocket gophers or by inhospitable territory, and is distant fully 150 miles from any other known population of the species.

In seeking to account for the geographic position of this population, one would, considering the present distribution of the remainder of the species, infer that at an early time its ancestors moved eastward along the south side of the Snake River and by geographic and biotic changes later were isolated. The finding (Wilson, 1933) of fossil remains of pocket gophers closely allied to *T. quadratus* in the Upper Pliocene or Lower Pleistocene beds near Hagerman on the south side of the river, however, might argue against this. Migration along the north side of the river is even less likely because of the vast lava fields that have been in existence, and at times active, since the Miocene.

Structurally, individuals of *similis* are most like specimens from near Halleck, Nevada, and accordingly it seems probable that the race might have been derived from that stock. The headwaters of the Humboldt River are but a few miles west of the westernmost limits of the Pleistocene Lake Bonneville, that at one time drained into the Snake River by way of Red Rock Pass and the Portneuf River. Perhaps by keeping to the deeper soils along the northern margin of this lake and its former outlet, migration to the area near Pocatello was accomplished. Since only *Thomomys quadratus* now is known to occur in the country immediately south of Pocatello, however, and since no specimens of *Thomomys townsendii* have been recorded from Utah, this hypothesis also has serious objections.

Each of two females collected February 23 contained 5 embryos 10 mm. in crown-rump length. A short, early breeding season is indicated by the fact that none of the 13 specimens taken in May, June, and July contained embryos. By June 1, young of the year are two-thirds grown.

Records of occurrence.—Specimens examined, 26, as follows: *Bingham County:* 1 mi. E. Pingree, 4. *Power County:* 4 mi. N.W. American Falls, 2; 2.5–5.5 mi. S.W. Michaud, 2. *Bannock County:* Fort Hall Indian School, 10 mi. N. Pocatello, 2; Pocatello, 15 (1 in Ralph Ellis coll.); 4 mi. N. Pocatello, 1. Additional records (Bailey, 1915): *Power County:* American Falls.

Thomomys vetus, new species

Holotype.—Nearly complete right mandible; no. 33041, Univ. Calif. Mus. Paleo.; Fossil Lake, Lake County, Oregon; Pleistocene age; collected by Chester Stock and E. L. Furlong in 1923–24.

Paratypes.—Fragments of two mandibles, lacking incisors and M_3, no. 26908; portions of two rostra, including palate and most of upper cheek teeth, nos. 26908 and 26907; and mandible, no. 33042, which is thought to have come from same individual as holotype; Univ. Calif. Mus. Paleo.; collected at same time and place as holotype.

Synonym.—*Thomomys townsendi*, Elftman, 1931, p. 10, part.

Characters.—A pocket gopher closely related to Recent *Thomomys townsendii*. Lingual faces of M_1 and M_2 rounded; anterior borders of incisive foramina situated posterior to alveolus of incisor a distance equal to 53 per cent of the diastemal length; rostral breadth, 9.5 mm.; alveolar length of lower tooth row, 9.1; alveolar length of upper tooth row, 9.2.

Comparison.—Differs from all Recent individuals of *Thomomys townsendii* examined as follows: Lingual faces of M_1 and M_2 rounded, rather than anteroposteriorly compressed; incisive foramina situated posteriorly to alveolus of incisor a distance equal to 53 per cent, rather than more than 60 per cent, of diastemal length.

Remarks.—Material available to me from Fossil Lake has been examined and commented upon by Elftman (1931), who referred it all, as well as additional material in the American Museum of Natural History, to *Thomomys townsendii*. The material here named as *T. vetus* is of the *townsendii* group, but Elftman was in error in similarly allocating *Thomomys scudderi*, which clearly is of the *Thomomys bottae* group, as was pointed out by Hay (1921) in the original description. Although these fossil remains of *T. vetus* closely resemble Recent *townsendii*, they differ from it to a greater degree than any of the races of *townsendii* do from one another. Of the two major groups of that species, *vetus* appears to be structurally more like the one, characterized by a broad rostrum, that now occurs in southeastern Oregon, northeastern California, and portions of northern Nevada.

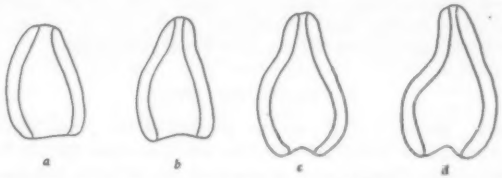

FIG. 4. Outline drawings of occlusal surfaces of right M_1. a. *Thomomys vetus* (type); b., c., d. Variations in size and shape of *Thomomys townsendii*. Anterior direction toward the right.

FIG. 5. Outline drawings of mandible and rostrum of *Thomomys vetus*, x1. a. Right mandible of holotype; b. Rostrum, Univ. Calif. Mus. Paleo. no. 26,908, as seen from the left side.

The deposits at Fossil Lake are thought to have accumulated over a considerable period of time. The occurrence of two species of pocket gophers at this locality can be explained by assuming that they occupied adjacent ranges in that general area at the same time, or that a change in the habitat here resulted in the withdrawal of one species and the invasion of the area by another. In Recent time two kinds of pocket gophers are not known to occur together; their ranges are complementary. It is possible, of course, that the type locality of *T. scudderi* might not be the same as that of *T. vetus*; Hay (*loc. cit.*) designated it as Christmas Lake, which lies 5 miles southwest of Fossil Lake. Elftman (*op. cit.*), however, is of the opinion that all fossil material designated in the literature as from Christmas Lake, Silver Lake, and Fossil Lake is actually from one deposit for which he considers the name Fossil Lake most appropriate.

As judged by Hay's description and figures of the type specimen of *T. scudderi*, he assuredly was not dealing with a member of the species *townsendii*. That his specimen is a *bottae* type of pocket gopher, to which group *townsendii* also is related, cannot be

questioned, because the position of the infraorbital foramen in *scudderi* is exactly that found in Recent *Thomomys bottae*. A single right mandible in the University of California Museum of Paleontology, no. 3343, lacking M_3, agrees in most respects with Hay's figure of *scudderi*. As judged from the degree of development of ridges for muscle attachment, and from the well developed angular process, this dentary is from a subadult of the *bottae* group and certainly cannot be a young individual of the much larger *vetus*, as Elftman may have thought when he studied the specimen. *Thomomys vetus* differs from *scudderi* as follows: Larger; dentary 20 per cent longer; teeth larger, angular process nearly twice as large. Hay (*ibid.*) pointed out similarities between *scudderi* and *Thomomys bottae*.

Thomomys scudderi and *Thomomys vetus* were collected in a region now uninhabited by their Recent counterparts. *Thomomys bottae* now occurs farther south and *Thomomys townsendii* farther east. *Thomomys quadratus*, so far as known, is the only species of the genus found in the region of Fossil Lake today.

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NOTES ON THE GENUS CHINCHILLA

By Theodor Carlos Bidlingmaier

The following pages comprise portions of a much longer discussion of the chinchilla sent by Mr. Bidlingmaier to the American Committee for International Wild Life Protection. The Committee has prepared the more pertinent parts of these discussions for publication herewith, and, with the help of Dr. Glover M. Allen, has endeavored to fit to accepted usage the classification that the author employed. This is based largely on the treatment of Prell (Zool. Anz., vol. 108, nos. 5–6, 1934). Our chief interest, of course, is in the information on habits, economic value, rarity, methods of capture, and exploitation of the several species. The classification appears to be as follows:

Chinchilla chinchilla (Lichtenstein), 1829, from Peru, of which *C. brevicaudata* Waterhouse, 1848, appears to be a synonym. Occasional on the western slope of the coastal cordillera, south latitude 9 to 33 degrees. It is exclusively a mountain animal. The best pelts are said to come from Oruca, Tacna, and Arica. Bidlingmaier evidently refers to this animal by the local name of chinchilla reale, or true chinchilla. He refers to it as being found only in Peruvian territory, and considers that it is now extinct. Recent expeditions, he says, have been conducted through its former range but without finding any rodent of this genus. He thinks that this species was of small size, but Prell said it is 36–38 cms. in body length, and therefore somewhat larger than *C. boliviana*. The fur is very long and soft, with a "matted and bunched appearance and lead-blue silver" in coloration.

Chinchilla boliviana Brass, 1911, occurs in the eastern Andes, northern Argentina, and southern Bolivia. It is a mountain species with a pelt so similar to that of *C. velligera* that the average individual cannot distinguish between them. The pelts, according to Prell, were formerly marketed in Buenos Aires. This without doubt is the animal referred to by Bidlingmaier as the chinchilla royalle, which he says today is on the verge of extinction, the few surviving individuals being confined to a relatively small area in the southwestern portion of Potosi Province in Bolivia. Under this heading, perhaps, may be included the vernacular names chinchilla indiana and chinchilla de la chileano cordillerano of Bidlingmaier's manuscript. The indianas, he says, are extinct in the wild, but a few have been re-established and are under close scientific observation—where, we do not know. The chileano cordillerano variety, he remarks, survives only in the very highest parts of its former range, at an altitude of 3200 meters or more, in the far northern Chilean provinces of Antofogasta and Atacoma.

Chinchilla velligera Prell, 1934, also called Bennett's chinchilla, is found about the Rio Chuapa, 32 degrees south latitude, and northward perhaps as far as latitude 25 degrees, or even farther. It is not as numerous in the moun-

tains as in the hilly country near the coast and in the inland valleys. It is small, with body length of only 20 to 25 cms. This evidently is the animal that Bidlingmaier designates as chinchilla de la costa, which he says was found formerly at lower altitudes, but persecution has caused it to retreat to constantly higher territory. The animal has been greatly reduced but still exists in fair numbers, and if given adequate protection, might re-establish itself, Bidlingmaier believes, in 7 or 8 years.

No doubt, in the trade at least, there has been some confusion between the true chinchillas and the rock-hoppers, *Lagidium*, which are sometimes called bastard chinchillas or viscachas. These latter have a very inferior pelage and were once considered as of little value, but because of the scarcity of chinchillas, *Lagidium* pelts recently have been accepted by the raw fur markets of Europe.

In general, the chinchillas are nocturnal, Bidlingmaier says, seldom venturing from their caves and dens until after sunset. If found abroad in the day time they are seldom far from their homes. Their food consists of a great variety of seeds, herbs, roots, and especially the "quiscos," a native pine bush bearing a fruit called "guillaves," which is carried into the dens.

It seems that formerly most of the Chilean pelts were purchased by buyers in Coquimbo, and information from the Customs Office of that city show the following quantity marketed:

1905	18,153 dozen	$100 to $110
1906	9,776 dozen	$130 to $140
1907	4,275 dozen	$160 to $170
1908	3,084 dozen	$140 to $150
1909	2,328 dozen	$400 to $500
*1931–36	213 kilos value	$1,615 Pds. Stlg.

* (Last governmental report recorded through the Aduana at Valparaiso.)

The raw pelt exporters have buyers in all the distant parts of the country, and the prices have increased enormously, as the above table shows. Raw fur buyers from European markets give instructions to their agents to purchase skins at any price, the demand each year tending to increase the greed of the native trapper, the chinchillero, who is tireless in seeking new and more destructive methods of hunting. Owing to an error in including hundreds of dozens of skins that were exported through the northern ports of Chile, estimates have been almost double those of the actual number coming into the markets. The trapping is followed throughout the entire year, regardless of the period of propagation.

Nothing terrifies the chinchillero, who pushes higher and higher into the altitudes of extreme thin air, often into places among crags and cliffs where his life may be in danger, with the single thought of obtaining the beautiful skin of this unfortunate little fur-bearer. He trails with a tenacity worthy

of better employment, and with a greed for wealth that seemingly cannot be satisfied. This hunter actually receives from the field buyers a sum equivalent to only 30 or 50 Chilean pesos for each skin. Through this persecution the total destruction of the species is annually more imminent. Without some adequate protection, there is no possibility that the rodents will be able to re-establish themselves.

At first there was a sufficient number of chinchillas to be caught with traps and with dogs; but little by little, other and more exhaustive methods were employed. Presently they were driven from their dens by the use of smoke. These little rodents are thus obliged to abandon their homes, or else be suffocated. If they leave the den, they almost always are quickly caught by the perro or dog, that is eagerly awaiting at the mouth of the tunnels.

A few of these valuable little fur-bearers prefer to die within their dens rather than to be trapped; in such instances, the chinchillero employes a long flexible stick, which is passed through the tunnel into the den proper. This is twisted until it becomes entangled in the fur of the rodent, which is thereby withdrawn from the den.

If this method fails, the tunnel is barricaded with stones, this blockade being left in place for a period of two days. Then, because of hunger, the rodent attempts to escape, and in this case it is generally felled by a stone cast from the trapper's sling shot.

In any region where signs indicate that a family of chinchillas may reside, an enclosure is erected, this being constructed of sticks and burlap, salvaged from sacks, which is sewn together, end to end, thereby forming a great length of this material. This barricade is constructed in circular form, with one portion terminating in a funnel-shaped outlet. At this point pitfalls are usually dug, being cunningly concealed so that when the chinchillas scamper upon the roof they immediately drop into a chamber beneath. Another plan of procedure is to erect similar barriers, and within the confines to destroy the vegetation. At the same time the extent of the burlap circle is reduced, little by little, until at last there remains only a small area within which the operations can be conducted.

Haste is of no material importance to the chinchillero, for he realizes that there is no one about to molest him in his activities, and that his patience eventually will be rewarded. By this systematic destruction, what few chinchillas remain are, by the destruction of their natural food, being forced into higher and higher elevations, and finally into regions where such natural foods do not exist. In other instances the vegetation is burned off, this method completely destroying the native "bulsa-mocarpum brevifolium" or algarrobilla, over large areas.

Apparently it is of no use to limit the trapping to certain months of the year, because of the ignorance of the native trappers, who carry on this

illicit hunting of all species with an endless patience unequalled in any other part of the world. The system as now employed will certainly end in total destruction and, unless laws are enforced to save this most valuable fur-bearer, within a very short period of time all of the remaining species will be exterminated. The native chinchilleros are tenacious, and although a pelt only brings them a very meager reward for their arduous labors, it seems to them like riches. They operate over the entire territory of the provinces previously mentioned, and most surely there is not a spot left in these sierras that has not been explored by them.

It is a well established fact that legal protection in the sierras of the Atacama and Coquimbo provinces is practically impossible. Because of its enormous extent it would be very costly to have this territory thoroughly patrolled. Even considering the high character and efficiency of the carabineros, the chinchillero, knowing the regions from a childhood of adventure with his father and other hunters, could easily escape into places where he would never be discovered.

Better results would follow the enactment of stringent laws especially aimed at the traffic in contraband skins. Many skins of chinchillas are now exported by being smuggled over the high cordilleras to Argentina. First they are taken across the frontier into Bolivia and thence smuggled southward and eastward through Argentina. The skins now smuggled from Chilean ports are relatively of no importance, inasmuch as this government for the past 15 years had controlled the situation fairly well by the enactment of laws that give strict protection to these valuable fur bearers.

It is claimed by certain interests in the chinchilla industry that the poorer working classes of Atacama and Coquimbo provinces derive much benefit from the wages paid for their trapping services. This, unfortunately, is not as true as it appears, for the reason that it is impossible for the average common laborer to become a proficient chinchillero because of the initial investment required to equip even a small expeditionary force of hunters, whereby these men can live in the high and desolate regions of the cordilleras, leading a seminomadic life for 6 to 8 months before even a dozen skins may be collected and sold.

With his catches collected, the hunter slowly returns to points where he meets the field-buyers of the raw skin brokers. His catch sold, he proceeds toward some commercial center to purchase supplies, and thus re-outfit for a new expedition.

Some people claim that the absolute prohibition of all commerce in chinchilla skins over a period of years would have the effect only of raising the now fabulous prices to even higher figures. It seems logical, therefore, to encourage a much more thorough scientific study of the status of these rodents in their remaining habitat, while at the same time other investigations

and studies should be made of their reactions to confinement and to breeding under domestication.

Some efforts to breed these animals in confinement have been attempted in Chile in the vicinity of Vallenar and Copiapo, where in the nearby sierras grow the several varieties of the algarrobilla. Nothing of great value has been revealed by the government, nor by most private enterprises. Apparently, through economic necessity, the experimental criadero at La Serana was closed some two years ago. Today there remain only five licensed criaderos (breeding farms), two of which are now presumed to be working in conjunction with a syndicate from the United States, which some 15 years ago, under the direction of a former employee, smuggled a number of coasterino chinchillas out of Chile.

The foregoing is merely a synopsis of Mr. Bidlingmaier's paper. The Committee wishes to call attention to the unfortunate situation of the mammals of the genus *Chinchilla*. We know little enough about the possibilities of rearing these animals in captivity. It would seem that here is a worthwhile problem for some western agricultural college situated in a high, dry climate. Attempts at farming in the United States, thus far, have been confined to commercial breeders and surrounded with much mystery and secrecy. We have not been able to ascertain anything about the governmental farms in Chile and Argentina.

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INSECT FOOD OF SKUNKS

By George Hills Kelker

In the past few years there has been much controversy regarding the relationship of predators to game animals. Certain groups of people wish to protect all predators, while others desire to have the predators severely reduced or locally exterminated. Either policy seems unwise, for predators destroy injurious rodents and insects as well as game species. Therefore, to help establish the true status of predators in Michigan, H. M. Wight and Dr. Ned Dearborn collected data and material from areas throughout the state. This paper deals with the portion of that material collected on a wild life sanctuary located in the southeastern part of the state, where both game birds and predators were common.

Examination of the scats of the common skunk (*Mephitis nigra*)—one of the predators of debatable value—showed that insects are of noteworthy importance as a food for this animal. Therefore, in 1931 the writer, at the request of Professors Wight and Dearborn, identified the insects found in skunk feces in order to determine the ratio of injurious to beneficial forms as chosen by the skunk under natural conditions.

Previous studies on the food of skunks.—Scientists had previously determined that the skunk's food is, to a large extent, composed of insects. Lantz (1923) reported from a study of three genera of skunks that the insects eaten were chiefly grasshoppers, crickets, cicadas, army worms, hop grub or hop borer, white grubs, beetles, tobacco worms, sphinx moths, and Colorado potato beetles, as well as many beneficial yellow-jackets and bumblebees. Chamberlain (1928) on feeding insects to his captive skunks, found that the most important order chosen was Coleoptera, with Lepidoptera second, and Orthoptera third. On feeding 57 species, representing 7 orders of insects, he found that 40 were eagerly eaten, 9 were indifferently eaten, 6 were refused, and 2 were of doubtful status. Of the 8 species of Hemiptera fed, not one was eagerly eaten.

Dixon's (1925) examinations showed that of the insect food, 24.9 per cent was of harmful forms, 1 per cent neutral, and 0.4 per cent beneficial, these three groups equaling 26.3 per cent of total food by volume. He added that trappers found insects in 207 of the 353 stomachs examined, which is an occurrence of 58.6 per cent. Likewise, Hamilton (1936) found over a 7 year period that insects rated first among the many foods eaten during the spring and summer months, but were third in the fall and winter months. Of 1067 skunks examined during fall and winter, 276 (24.9 per cent) had eaten insects, which comprised 6.8 per cent of the total bulk. But during spring and summer, the 30 stomachs and 570 scats examined had 247 instances (57.8 per cent) of insects, which had a frequency percentage of 43.06 of all foods eaten.

Further investigations recently made at the School of Forestry and Conservation, University of Michigan, by Wight (unpublished manuscript) and by Dearborn (1932), strongly support these findings. Dearborn's examination of visceral contents and feces of nearly 700 skunks during summer and fall showed that insects comprised more than half of the total food. He found that Orthoptera are eaten in greater quantities than are Coleoptera. Of the latter order, more May beetles are eaten than carabids. Representatives of three other orders were the Lepidoptera (particularly cutworms and caterpillars), Hymenoptera (bees and hornets), and a trace of Hemiptera.

Methods of analysis.—The first examination of the air-dried scats determined the major classes of food, such as insect, mammal, or fruit. Afterwards, the insects were identified, and the proportion of each group was determined volumetrically for each scat or group of scats. The results were recorded in terms of percentages. The total proportion for any order was found by adding the percentages of the families comprising that order.

Since the purpose of the study was to determine the amount of insects in the injurious and beneficial classes, no further attempt was made to identify forms beyond the degree of accuracy needed in the study. The family, therefore, was chosen as the smallest taxonomic unit, for, as a general rule, the feeding habits of the genera comprising a family are quite similar from an economic viewpoint.

Time of collection of scats.—Of the 101 scats collected between June and early October, 1929, 68 were secured in August. In 1930, 201 scats were collected between early March and late October, of which total 147 were taken in July. The 1931 collection of 650 scats was made in September.

Insects preferred as food.—The ratio of insects to other foods, based on volumes, may be seen from the following data (Wight, unpublished manuscript, for 1929 and 1930 data). Furthermore, analysis showed that the individual scats of September were more likely to be wholly of insects than those taken earlier in the year.

In 1929	insects	comprised	67.8%,	all	other	forms,	32.2%
" 1930	"	"	53.5%,	"	"	"	46.5%
" 1931	"	"	70.1%,	"	"	"	29.9%

In comparing the amounts of different foods, as determined by scat analysis, a reservation must be kept in mind. It is necessary to consider that the ratio of the remains of several substances eaten is not the same ratio as that of the original substances before consumption, whether determined by volumetric or weight basis. For example, if ten scats of a skunk showed a one-to-one ratio of mouse hair and bones to the chitinous remains of insects, it does not prove that they were eaten on a one-to-one basis. The relation of waste to the original bulk or weight of any food after passing through the

TABLE 1

The Insect Food of Skunks for 1929 and 1930 in Southeastern Michigan

Expressed in Percentages of Total Volumes of Insect Food for Each Semi-monthly Period

TIME INTERVAL	COLEOPTERA								ORTHOPTERA						HYMENOPTERA		UNKNOWN	
	Carabidae		Scarabaeidae		Other Families		Total		Gryllidae		Acrididae		Total		Vespidae			
	'29	'30	'29	'30	'29	'30	'29	'30	'29	'30	'29	'30	'29	'30	'29	'30	'29	'30
April 1–15								0.0										
16–30		50.0				50.0		100										
May 1–15		100						100										
16–31						100		100										
June 1–15								0.0						0.0				
16–30	50.0	80.0		20.0			50.0	100						0.0	25.0		25.0	
July 1–15		92.9		2.7		4.2		99.8		0.1				0.1			0.0	0.1
16–31	79.3	45.1	2.4	29.9	5.5	7.3	87.2	82.3	5.0	8.7			5.0	8.7			7.8	9.0
August 1–15	18.0	43.6	57.0	14.3			75.0	57.9	9.0	21.4	10.0	20.7	19.0	42.1			6.0	0.0
16–31	39.6	46.9	5.6	9.4	11.5		56.7	56.3	30.6	30.6	1.0	1.0	31.6	31.6			11.7	12.1
September 1–15		33.0	50.0			34.0	50.0	67.0	50.0	0.0			50.0	0.0		33.0		
16–30		26.7				33.3		60.0		40.0				40.0				
October 1–15	100						100											
16–31							0.0			100				100				
Mean Value for the Year.....	39.2	61.5	27.5	14.4	4.8	6.9	71.5	82.8	15.3	10.7	4.2	1.1	19.5	11.8	0.6	0.7	8.4	4.7

digestive tract is yet to be determined. It is probably true that the method here used is accurate enough for practical purposes.

Types of insects eaten.—The insect food predilection of skunks during the summers of 1929 and 1930 was for beetles rather than for crickets and grasshoppers. The beetles were chiefly taken in the early part of both seasons, and were characterized principally by the two families Carabidae and Scarabaeidae. The latter were nearly all May beetles. The latter part of both seasons was characterized by the numerous crickets (Gryllidae) and grasshoppers (Acrididae). This change in type is remarkably verified in the results of the third year (Table 2, 1931). Here Orthoptera formed 98 per cent of the insect food, whereas Coleoptera, Hymenoptera, and other orders were of negligible importance.

A comparison of insect types for three similar periods is given in Table 2. The scats found in 1931 varied from fresh to less than four weeks old. There-

TABLE 2

Comparison of a Four Weeks Period—August 16 to September 13—for Three Years as to Insect Types Eaten by Skunks

Each Insect Group Expressed in Per Cent of the Total Bulk for the Time Indicated

YEAR	COLEOPTERA				ORTHOPTERA				HYMENOPTERA		UNKNOWN AND OTHER ORDERS
	Carabidae	Scarabaeidae	Other Families	Total	Gryllidae	Acrididae	Tettigonidae	Total	Vespidae	Sawfly Cocoons	
1929	37.0	8.7	10.7	56.4	32.0	0.7		32.7			10.9
1930	44.7	7.9	5.3	57.9	25.8	0.7		26.5	5.3		10.3
1931	0.9	0.1	0.1	1.1	70.6	27.2	0.2	98.0	0.1	0.2	0.6

fore the time common to each of the three years is from the middle of August to the middle of September. The difference between the results of the two groups may have been due to a difference in seasonal conditions, or in other words, the same ecological conditions of different years may not have fallen on the same calendar dates. But it is also possible that the comparatively small percentage of coleopterous insects in the skunks' 1931 diet was in part due to the cyclic nature of May beetles (*Phyllophaga*).

Not only is there a variation of insect types with respect to time, but also different areas of the same period of time do not support the same species of insects. Table 3 shows that two areas compared for 1929 differ chiefly with respect to abundance of carabids and scarabaeids. The lack of Orthoptera on area IID15 is due to no scats being found there in late summer. Likewise the two areas for 1931 have a divergence of carabids and scarabaeids; but the crickets are of nearly equal importance on each area. On the contrary, the one area (IID15) when compared for two years, does not show much change in kind of insects taken; for in 1930 the crickets represent a later time not covered by the preceding year.

Frequency rating.—This study lists 5 orders of insects, represented by 20 families including 20 known genera (Table 4). In 1929 and 1930 the May beetles (*Phyllophaga*) occurred the most times, with crickets (*Gryllus*) second, and grasshoppers (*Melanoplus*, *Schistocerca*, and *Dissosteira*) third. But in 1931 the crickets were first, the grasshoppers second, and the Calasoma beetle (*C. calidum*) third.

Frequency versus bulk as a criterion in determining food values.—A comparison of frequency rating in Table 4 with volumetric proportions in Tables 1 and 2 shows that the two methods do not agree as to important insects eaten. For instance, in the year 1931 the *Calasoma* beetle has a frequency of nearly 11 per cent, yet by bulk it is very much less, for all of the carabids do not comprise over 0.9 per cent of the total insect food. Likewise, the frequency rating of Vespidae is 7 times that of its bulk. Similarly, the data presented by Hamilton (1936) shows that merely stating the number

TABLE 3

List of Insect Families Eaten by Skunks on Two Different Areas in 1929 and also in 1930, One Area of Which is Common to Both Years

Each Insect Family is Expressed in Per cent of Total Volume

AREA	YEAR	COLEOPTERA				ORTHOPTERA			HYMENOPTERA	UNKNOWN
		Carabidae	Scarabaeidae	Other Families	Total	Gryllidae	Acrididae	Total	Vespidae	
IID2	1929	4.3	70.9		75.2	7.8	12.0	19.8		5.0
IID15	1929	94.0	1.9	0.7	96.6					3.4
IID15	1930	87.3			87.3	9.4		9.4	3.0	0.3
IC2	1930	51.2	37.4	2.7	91.3	8.6		8.6		0.1

of instances of insect occurrence is not as indicative of its true importance as giving the percentage of the total bulk. During the spring and summer months the number of occurrences, on a percentage basis, was two and one-third times as much as in fall and winter; but when compared by bulk on a percentage basis, it is found to be six and one-third times as great during spring and summer as in fall and winter. Thus, a list of frequencies alone may give a false impression as to the bulk of the food. Therefore, in rendering judgment on the food of any animal, the emphasis, whenever possible, should be placed on the bulk consumed and not on frequency ratings.

Factors influencing the choice of species.—The abundance of a given species is perhaps the most important factor causing variations in the quantities of the desirable species eaten by a skunk. Not only the availability of the different forms, but their activity at night may help the skunk in finding them. The latter circumstance may explain why more crickets than grasshoppers are taken. The smallest insects eaten were about 8 mm. long. Chamberlain (1928) stated that some species were apparently distasteful

TABLE 4

Frequency Rating of Insects Found in Skunks' Scats, Expressed in Per Cent of Number of Scats Containing Designated Insects to Total Number Containing Insect Fragments. Economic Values are Relative to Agriculture and Forestry

(B—Beneficial, I—Injurious)

TAXONOMIC GROUP IDENTIFIED	1929		1930		1931	
	B	I	B	I	B	I
TRICHOPTERA						
Molannidae						
Molanna (larval cases)					0.7	
HEMIPTERA						
Belostomidae					0.2	
Reduviidae					0.2	
ORTHOPTERA						
Gryllidae						
Gryllus		27.2		13.1		95.6
Acrididae		10.8		4.0		89.2
(*Dissosteira, Schistocerca, Melanoplus*)						
Tettigoniidae						1.1
COLEOPTERA						
Cicindelidae						
Cicindela	8.3		2.3			
Carabidae						
Calosoma	1.1		4.5		10.9	
Brachinus			2.3		0.3	
Lebia			1.1			
Chlaenius			2.8		0.2	
Harpalus	1.1		6.8		0.9	
Poecilus	4.3		4.0		0.2	
Unidentified	70.5		90.0		21.8	
Silphidae						
Silpha					0.2	
Coccinellidae						
Hippodamia					0.3	
Unidentified					0.2	
Elateridae		1.1		2.3		
Buprestidae						0.7
Lucanidae						
Lucanus						0.2
Scarabaeidae						
Phanaeus					0.2	
Phyllophaga		36.0		20.4		2.7
Trox	1.1					
Pelidnota		2.2				
Cotalpa		2.2				
Unidentified				4.5		
Cerambycidae						0.2
Chrysomelidae						0.2
Curculionidae				3.4		1.1
HYMENOPTERA						
Vespidae			0.6		0.7	
Bombidae					0.2	
Tenthredinoidea (cocoons)						2.0

to skunks, for his captive animals refused certain Hemiptera after once biting them.

Economic status.—The economic status of any animal based on food habits is predicated on the economic value of its foods. The economic rating of the insect groups (Table 4) shows that the Carabidae is the only important beneficial order (both from standpoint of volume and frequency of occurrence) eaten by the skunks. Other beneficial families or genera are of negligible occurrence. In 1929, all of the injurious insects comprise more than half of the total insect food. In 1930, however, they were about three-eighths of total food (Table 1), but in 1931 they comprised 98 per cent of all insect food (Table 2). This study shows that the insect foods eaten during the early part of the summer are of equal values, but during the later part of summer the injurious species predominate in the food consumed. Therefore, the economic status of the skunk on this wild life sanctuary, when based solely on insect food, is of doubtful positive value in the early part of the season, but is of decidedly positive value for the late summer and fall seasons.

Acknowledgments.—This study was done in partial fulfilment of the requirement for the degree of Master of Science in Forestry at the School of Forestry and Conservation, University of Michigan. The writer is indebted to H. M. Wight, Dr. Ned Dearborn, and Dr. S. A. Graham for their many helpful suggestions. Doctor Graham further aided in the identification of certain insect forms. At the University Museums, Dr. F. M. Gaige assisted immeasurably in permitting the museum's collection of insects to be available for constant reference.

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PARALLEL RADIATION AMONG THE GEOMYOID RODENTS

By Albert Elmer Wood

It has long been realized by students of the group that the study of the evolutionary development of rodents has been greatly complicated by the tremendous amount of parallelism between different lines within the order. Nowhere else within the class is there so much parallelism, since among the rodents alone is there such a large number of closely related stocks that have been restricted to a limited amount of adaptive radiation. This tendency for similar evolutionary modifications among rodents is particularly well exemplified by the teeth. In part this is due to the similarity in the functioning of the cheek teeth, limited in variety by the uniformly conservative character of the incisors. In part it undoubtedly is due to some condition of the germ plasm, so that only a relatively small number of primary modifications of the primitive ground plan were possible.

The patterns of rodent cheek teeth may be fitted into a very limited number of types. There is what may be called the tuberculo-sectorial pattern, characterizing certain of the more primitive recent squirrels and certain fossil forms, and representing a reasonably close approach to the primitive mammalian ground plan. There is the multilophate type, which, with its subsequent modifications and simplifications caused by increasing but non-uniform hypsodonty, gives rise to the patterns found in certain other squirrels, the beavers, dormice, the Old and New World porcupines and their relatives, the South African spring-haas, and many others. A third pattern is fundamentally a combination of 5 cusps arranged in this manner ⁝·⁝ plus a series of connecting crests, with greater or lesser emphasis on cusps or crests. This pattern very often is the basis from which the multilophate type was derived. This five-cusped pattern is one of the most wide-spread of all the rodent patterns, having world-wide distribution in the Cricetidae, as well as occurring in numerous other groups, both fossil and recent. It may represent the ground plan from which the pattern of the Muridae has been derived. There are, of course, other patterns, but, with one exception, these seem to be the most important. It is with this one exception that I wish to deal at the present time.

The Heteromyidae and Geomyidae form a natural group, beyond all possibility of question, and entirely aside from the striking resemblances in their cheek teeth. Indeed, were it not for the extreme divergence between the mode of life and body form of the two groups, it seems certain that they would be considered as belonging to the same family. The time to have enabled the one group to develop forms with extreme leaping ability, and the other members that spend all their lives below the surface of the earth, must have been very long. Granted that the two groups could not have had a common ancestor more recently than the middle Oligocene at the very

latest, the question whether they should be considered two closely related families of the superfamily Geomyoidea, or two rather distinct subfamilies of the Geomyidae, is relatively unimportant. For present purposes we will accept the former alternative.

The foundation of the present type of cheek-tooth structure that occurs in these two families is well illustrated by the modern pocket mouse *Perognathus*. Here each molar, upper and lower, consists of two transverse crests of 3 cusps each, clearly distinguishable in unworn teeth. The lower premolar is quadrate, formed of 4 cusps, while the upper premolar has a three-cusped, crescentic posterior loph, with a single anterior cusp within the arms of the crescent, resembling the star within the arms of the crescent of the Turkish flag (Wood, 1933, figs. 2–3). While the type of tooth found in *Perognathus* differs in certain respects from the ancestral pattern, it is sufficiently close for our present purposes. Actually the closest known approach to the original pattern of the superfamily is found in the genus *Heliscomys*, from the middle Oligocene of Colorado, Wyoming, Nebraska, South Dakota and Montana. From this primitive stock there have been developed at least 7 distinct lines, each with slightly different characters or combinations of characters in the skulls and bodies, but each tending to develop certain very similar trends in cheek tooth evolution. The study of the evolution of these forms has enabled us to observe an interesting amount of parallel evolution at each stage in the history of the respective lines.

One of the most striking, as well as one of the most specialized, of these trends is the reduction of the enamel on the buccal and lingual margins of the teeth, so that merely anterior and posterior plates remain. This condition has been developed three times, entirely independently, within this superfamily. The condition in the modern pocket gophers has been described in considerable detail by Merriam (1895, pp. 78–80). The same sort of condition, although carried to no such extreme, has been pointed out by the present author in the case of the kangaroo rats (1935, p. 148, and figs. 77–90) and for certain extinct forms that may be intermediate in relationships between the heteromyids and geomyids (Wood, 1936, figs. 27–31). I am not familiar with any other mammal in which a similar set of shearing blades has been developed, although certain other rodents show a partial reduction of the enamel, never carried to the stage of formation of blades, however. And yet here, within a single closely related group of lines, the same specialization has developed three times, and has followed the same steps in reaching this end result. These are increased hypsodonty, with the enamel deposited farther down the anterior and posterior faces of the teeth than on the buccal and lingual ones; then the development of rootless teeth, and the limitation of the buccal and lingual enamel to a very short cap, and finally the elimination of the anterior enamel plate in the lower teeth and the posterior plate in the uppers, in the same manner that the lateral enamel had already been eliminated.

At least 4 groups, tentatively considered as subfamilies, have developed hypsodont cheek teeth, and in 3 of these, the kangaroo rats, the recent gophers and the fossil Entoptychinae, the process continued until the teeth were entirely rootless. The development of hypsodonty is not particularly striking, but the presence of so many groups with rootless molars is rather unusual in such a small series of lines.

Another character that has appeared several times, apparently entirely independently in each case, is the grooving of the upper incisors. All the recent genera of geomyids have longitudinal grooves in these teeth, which differ from one genus to another, and are used as one of the diagnostic characters of the respective genera (Merriam, 1895, pp. 70–72, figs. 20–24). Among the recent heteromyids, *Perognathus* and *Dipodomys* have grooved incisors, while the other genera have them entirely smooth. Of the fossil genera of heteromyids, the most primitive seem always to have had smooth incisors. Certain fossil forms, however, have developed grooves, similar in every respect to those of *Perognathus* and *Dipodomys*, even though they can by no stretch of the imagination be considered related to those forms (Wood, 1935). Indeed, the immediate ancestor of both *Perognathus* and *Dipodomys*, within the respective subfamily of each of these genera, seems to have had smooth incisors. Among the Entoptychinae, smooth incisors were the rule, but one form (Wood, 1936, p. 12) had developed shallow grooves in these teeth.

One very interesting feature possessed in common by all the living members of this group are fur-lined cheek pouches opening outside the mouth. These are absolutely unique, being found nowhere else among the Mammalia. It seems more probable, in spite of their complete absence elsewhere, that these form another instance of parallel trends in evolution rather than a heritage from a common ancestor. However, as we can never have any evidence on this point from fossils, we are free to adopt whichever point of view seems best to us individually.

In the lower premolars of the heteromyids, there are several distinct types that help to separate the various subfamilies. These already have been outlined in considerable detail (Wood, 1935, pp. 210–213, and fig. 147). Of these, the four-cusped type, found in *Perognathus*, is quite primitive, and, as suggested above, approaches the ancestral conditions. That it is not the most primitive condition to be found within the group, however, is suggested by the premolars of *Heliscomys*, with but 3 cusps. Therefore, when we find *Perognathus*, *Proheteromys* and *Mookomys* among the Heteromyidae, and *Pleurolicus* among the Entoptychinae, with the same four-cusped pattern, we are certain that there must have been a considerable degree of parallel evolution. A later stage of modification, starting from the four-cusped condition, is the development of a small accessory area in the center of the anterior end of the tooth, sometimes appearing as a cusp, sometimes merely

as a shelf. This is exemplified by *Liomys*, *Peridiomys* and *Diprionomys* among the Heteromyidae, and by *Grangerimus* and *Entoptychus* among the geomyids. A still further specialization has given rise to an anterior cingulum from which there budded off several cusps, equal in elevation to the remainder of the tooth. This stage exists in *Heteromys* among the heteromyids, and *Gregorymys* among the Entoptychinae, as well as in the milk teeth of numerous other forms. The methods followed by the Geomyinae in the evolution of this tooth are still uncertain, although this group seems to have evolved along lines similar to those known among the Entoptychinae and Heteromyidae.

In the molars of all members of the two families, the primary development in the dental evolution is the formation of 2 cross crests, composed of 3 cusps each. This stage of development has been reached by *Perognathus*, *Liomys* and *Heteromys* among the living pocket mice, by most fossil heteromyids, by *Pleurolicus*, *Gregorymys* and *Grangerimus* among the entoptychines, by *Dikkomys* from the Miocene, the earliest known geomyine, and by *Pliosaccomys*, a Pliocene geomyine of uncertain affinities (Wilson, 1936). This leads to the development of 2 separate types—those in which the crests unite first in the center, and those in which they unite first at one end or the other. The former is characteristic of the Geomyinae, and the latter of the Entoptychinae, while the heteromyids are divided about equally between the two conditons.

These indicated points of similarity are not characters inherited from a common ancestor. They are traits that have been independently developed by the different lines of the Geomyoidea since their divergence from the ancestral stock. Thus, if we base our ideas of relationship upon heritage characters retained from a common ancestor, they are not indicative of relationship. On the contrary, they are entirely habitus characters, developed under the actual conditions in which the animals in question are or were living. This statement, of course, must not be interpreted as suggesting that the habitus characters were *caused* by the environment, but merely that they were *permitted* by it. In general, paleontologists and taxonomists believe in basing the classification of any group on the heritage characters, and in using the habitus characters merely as points by which to differentiate various subordinate groups. In the present instance, however, it seems that although both the heritage and the habitus characters are to be used in showing that these rodents are related, yet the relationship indicated by the heritage characters might be only a broad and distant one, whereas the similarity of their habitus characters force us to unify the group into a single cohesive whole.

These 7 or more lines have had an independent history for 15 million years or longer. Since these lines separated, they have undergone considerable evolution, and yet have remained closely parallel at all stages. It is this

tendency that elsewhere (1935, p. 249) I have called "parallel radiation". It is interesting to note that while various of these groups have developed identical, or essentially identical, structures in their teeth or in other parts of their bodies, they have effected this at different periods in their evolutionary history, which fact alone enables the paleontologist to disentangle their histories. This parallelism might be interpreted as an orthogenetic tendency were it not that there is no direct evidence of orthogenesis as an actual process anywhere, and that such a process is definitely opposed by the evidence from genetics.

At the time when these groups separated from their common ancestor, they must have had a fundamentally identical genetic composition. Their subsequent evolution has consisted solely of random mutations of these ancestral genes, followed by an intensive application of natural selection. As the original genes were essentially the same in all groups, not only would the possible mutations be similar in each line, but subsequent mutations would have similar if not identical effects. A well known example of this similarity of effect is the albino mutation, which affects large numbers of quite diverse groups of vertebrates in identical fashion. As is only natural, the greater the similarity in bodily structure between two forms, or in other words, the more closely they are related, the greater will be the number of mutations that have identical effects.

This extreme parallelism in evolutionary trends, which is here emphasized as a character of the cheek teeth of the geomyoids, occurs frequently throughout the entire order of the rodents. I have confined myself to the one superfamily, partly for the sake of clarity, partly because I am most familiar with the evidence for the evolution of this group, and partly because, at the present time, more is known of the detailed evolution of the geomyoids than of most or any of the other groups of rodents. The rapid accumulation of great quantities of data on the evolutionary history of the other families of the order shows that parallel radiation has been the fundamental feature of the history of the rodents, and future work undoubtedly will serve to increase the number of lines known to have evolved from a common ancestral stock in identical or nearly identical directions. The closer the relationship, of course, the closer will be the parallelism, provided that the environmental selective stimuli are similar, as in the case of the heteromyids and geomyids. Hence, when there are such similar trends as have been pointed out among the geomyoid rodents, one may be sure that there is a very close relationship between the groups.

I do not, however, advocate uniting these rodents into a single family. As long as there is a reasonable doubt on the matter, it would simply confuse the nomenclature to do so. There are unquestionably groups subordinate to the Heteromyidae and Geomyidae. If the families were reduced to subfamilies, these subordinate groups would have to be infrafamilies, which

is a rather awkward terminology, and, it seems to me, underestimates their importance. Finally, it is extremely gratifying to be able to say that here, at least, are two families of rodents that everyone is willing to admit are closely related; and which appear actually to be related in spite of the unanimity of opinion.

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BREEDING HABITS OF THE FREE-TAILED BAT

BY H. B. SHERMAN

The breeding habits of the free-tailed bat of the southeastern United States, *Tadarida cynocephala* (Le Conte), have been investigated as a part of a study of the life history of this species. These bats are locally abundant in Florida, and in some places large colonies of them occur in buildings. For many years a colony has occupied parts of an old building in Gainesville, and this is the source of all of the material herein discussed.

For assistance in this work I wish to make the following acknowledgements: The Museum of Zoology of the University of Michigan granted me a fellowship, the use of its library, and numerous other facilities; the suggestions of L. R. Dice were particularly valuable. In addition, the Department of Zoology of the University of Michigan furnished me with laboratory facilities for microtechnique by means of which I made many of the slides mentioned later. On two occasions A. F. Carr and Dr. Wesley Clanton collected specimens for me at a time when I was unable to do so. For the aid received from these sources I wish to express my indebtedness.

The section of the building where these bats roost (fig. 1) is used primarily for the storage of fertilizer. The bare rafters and rough board partitions of these poorly lighted rooms furnish suitable quarters for this species, as shown by the fact that more than 10,000 individuals usually are present from June

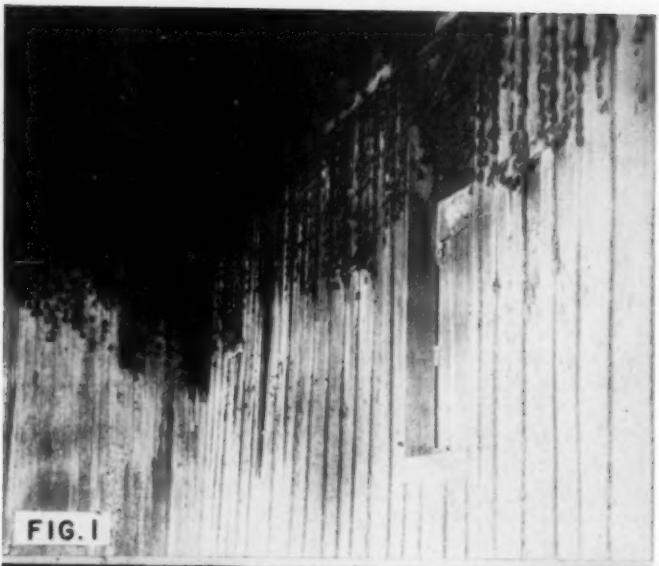
until early autumn. At the top of the partitions, a series of crevices are favorite retreats. These are about one foot in vertical extent by one inch in depth, and vary in width from 3 or 4 inches to as much as 2 feet. The only other species of bat that I have found here is *Myotis austroriparius* (Rhoads), individuals of which are present only occasionally and in relatively small numbers.

The number of *Tadarida* in the building decreases as the weather becomes colder in the autumn, although several hundred usually are present throughout the winter months. The severe winter of 1934–1935 was exceptional in this respect, for only a few bats were present in the building during the coldest weather. Few or no bats were found in the building for about a week in March throughout a seven-year period, 1929–1935, and evidence presented later indicates that copulation occurs at this time. Nearly all of the bats found in the building at this time are immature males.

When the bats return, nearly all of the females are pregnant. The earliest date on which I have evidence of ovulation in this species is March 17. Two adult females captured March 15, 1934, were kept in an unheated room for 2 days before they were dissected. Serial sections of the reproductive tract of 1 of these individuals show a partly formed corpus luteum in the right ovary and an egg in cleavage, consisting of 2 cells, (figure 2) in the right tube. Ovulation had not occurred in the other individual nor in 5 adult females taken March 7, 1933. Ovulation had occurred in 18 bats of this species taken March 23, 1929. At least 16 of these contained embryos ranging in development from morulas in the tube to embryos in the uterus with germ layers differentiated. Sections saved of the other individuals show no embryos; but these series are incomplete. The presence of a corpus luteum in the right ovary of each of these 2 specimens shows, however, that ovulation had taken place. From early April to the first of June non-pregnant females of this species were very rarely found.

The time of ovulation in the *Tadarida* of the colony studied is quite restricted, judged by the dates when young were born and by the measurements of embryos taken on a single date. It is generally understood that fertilization in mammals takes place soon after ovulation and all recent authors agree that embryological development of bats ensues at once after fertilization is accomplished, thus disagreeing with the theory of Van Beneden (1875) that development is delayed with some species of bats for several months after the fertilization of the ovum. For these reasons, and assuming that the period of gestation is constant, the extent of the time of parturition and the size of embryos furnish reliable evidence as to the duration of the time of ovulation.

The earliest date of parturition in *Tadarida cynocephala* for which I have evidence is May 31, 1929. One of the 10 females taken on this date had recently given birth, as indicated by the greatly enlarged but empty uterus.



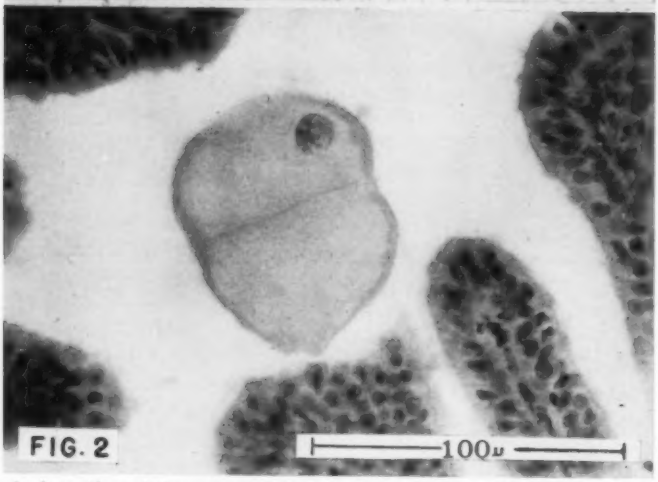


FIG. 1. A portion of the colony of *Tadarida cynocephala* under discussion, photographed September 7, 1931.

FIG. 2. Section of a segmented ovum of *Tadarida cynocephala* in the fallopian tube of a specimen taken March 17, 1934.

I was unable to find young among the colony on this date, however, or on June 2, although many were present June 3. Most of the young, estimated to be about 4000 in this colony, had been born by June 11, 1929, for on this date many females were captured before a pregnant specimen was found.

In 1931, the time of parturition was about a week and a half later than in 1929, as shown by the following observations. The majority of the adults of this species leave the building a few minutes after sundown, but fail to take their young with them. A thorough examination of the building after most of the bats had left on the night of June 10, 1931, resulted in finding no young. Three nights later, 350 young were counted in or near 19 of the crevices at the top of a partition, which is the place where nearly all of the very young bats of this colony were found. On the night of the 15th, 567 young bats were counted, while on the night of the 17th, at least 1459 young were present. It seems certain that many more were not seen, however, as they were crowded together and retreated into the crevices at the approach of the light. On none of these occasions were the young removed from their resting places. On June 24 of the same year most of the young had been born, and 4 days later several hundred females were captured before a single pregnant specimen was obtained. On June 29, 1931, no pregnant females could be found in the colony during a search of two hours. The pregnant female captured June 28 gave birth to a young one on June 30, 1931, which is the latest date for which I have evidence of parturition in this species.

It is thus evident that nearly all of the young *Tadarida* were born within an interval of 2 or 3 weeks, from May 31, or a day or two earlier, to June 11, 1929, and from June 13, or a day or two earlier, to June 30, 1931.

The lengths *in utero* of all of the larger embryos of this species taken in 1929 are indicated in figure 3. The smaller embryos, all of which were taken before April 8, were not measured. With the exception of a 3.5 mm. embryo taken April 23, there is no great variation in the size of embryos taken on the same day. The extremes in size of embryos taken April 23 (3.5 to 14.5 mm.), in comparison with the size of embryos taken on other dates, seems to indicate a difference in age of about 3 weeks. The relatively small amount of variation in the size of other embryos taken on the same day is apparently due to a difference in age of but little more than a week, as shown by comparing the size of the largest embryo taken on a certain day with that of the smallest embryo taken a week later.

All of the larger embryos taken on the same day in 1930, indicated in figure 3, show about the same amount of variation in length as those taken in 1929, but parturition occurred at about the same time in 1930 as in 1931 and the embryos are correspondingly smaller in the 1930 series than those taken on a corresponding date in 1929. June 12 is the earliest date that young were found in 1930. Thus the extent of the time of parturition and

the size of embryos taken on the same day indicate that ovulation occurs with virtually all female *Tadarida* of the colony studied within an interval of 3 weeks in one year, and in 9 out of 10 cases it probably occurs within an interval of but little more than a week. In different years the duration of the time of parturition, May 31 or a day or two earlier, to June 30 in 1929 and 1931 respectively, indicates that in this colony ovulation takes place during an interval of about one month.

The time required for the development of the various stages of small embryos of *Tadarida cynocephala* is unknown. It seems probable, however, that 2 morulas, a single one found in the right fallopian tube of each of 2 specimens taken March 23, 1929, are less than a week old. Such being the case the preceding evidence indicates that ovulation and fertilization oc-

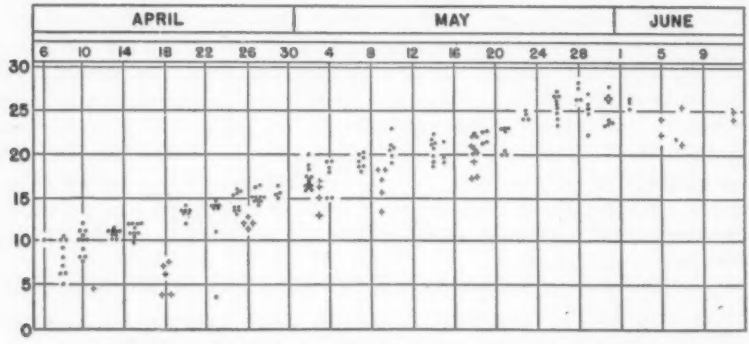


FIG. 3. Length *in utero* of embryos of *Tadarida cynocephala*, measured in millimeters. Those taken in 1929 are designated by dots, and those taken in 1930, by crosses.

curred in most of the *Tadarida* of this colony during the second and third weeks of March in 1929, and about one and one-half weeks later in 1930 and 1931. March was colder in 1930 and 1931 than in 1929, and this possibly is the reason for the later dates of ovulation in these years.

The period of gestation in this species, judging from the evidence here presented, is between 11 and 12 weeks.

It is of interest to note that, relative to the time of ovulation, large ovarian follicles are present in these bats in all months of the year. The number of vesicular follicles, determined by means of serial sections, found in both ovaries of specimens taken in all months of the year, is given in table 1. This evidence shows that the only time when large follicles are uniformly absent is when small embryos are present. The vesicular follicles are mostly present in the right ovary only, but 4 of these were found in the left ovary of 1 specimen, 2 in 2 other specimens, and 1 in each of 7 others from a total of 82 individuals.

TABLE 1

COLLECTION DATE		NUMBER OF VESICULAR FOLLICLES PRESENT IN BOTH OVARIES	NUMBER OF SPECIMENS	EMBRYO IN TUBE	EMBRYO IN UTERUS	EMBRYO A MORULA STAGE OR YOUNGER
January	17	8, 10, 11	3			
	20	10, 12	2			
	29	17	1			
February	5	17	1			
	15	15, 24	2			
March	7	6, 11, 11, 12, 13	5			
	17	12	1			
	17	0	1	x		x
	23	0	1	x		x
	23	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	11		x	
	24	0, 0	2	x		x
	24	0, 0, 0, 0	4		x	
	24	10	1		x	
	26	0	1		x	x
	26	6	1		x	
April	1	8	1		x	
	4	3	1		x	
	11	3, 7	2		x	
	18	7, 9, 10, 13	4		x	
May	7	0	1		x	
	10	0	1			
June	18	11	1			
	25	6	1			
July	14	0, 1	2			
	24	4, 5	2			
August	7	1, 5	2			
	17	10	1			
	28	7	1			
September	8	19	1			
	19	8	1			
	30	3, 5, 5, 13	4			
October	14	9, 13, 16	3			
	17	8, 8, 10	3			
	24	7	1			
November	8	2, 2, 4, 4, 6, 8	6			
	12	14, 20	2			
December	10	11, 11, 12	3			
	23	17	1			

That all but 1, or rarely 2, of these large follicles atrophy without the occurrence of ovulation is shown by the fact that only 1 corpus luteum was found in the right ovary of 30 specimens, and in 1 specimen 2 were present. None was found in the left ovary. All of the specimens in which corpora lutea were found were taken during the time of gestation, from the middle of March to early June.

Spermatozoa were found in the female reproductive tract of but 5 of the many specimens examined. These were captured February 13, 1932; February 27, 1932; 2 specimens March 7, 1933; and the fifth specimen March 23, 1929. Of these 5, ovulation had taken place only in the specimen taken March 23, and this individual contained an embryo with the central cell mass somewhat separated from the trophoblast. This indicates that mating occurs, in various years, during a period of somewhat more than 5 weeks and at about the time of ovulation in the *Tadarida* of the colony studied, and that spermatozoa are not stored in the female reproductive tract of this species of the Molossidae as is known to be the case for several species of the Vespertilionidae and Rhinolophidae. For a review of the literature dealing with the survival of spermatozoa in the genital tract of bats, see Guthrie, 1933; Hartman, 1933; Hamlett, 1935; and Gates, 1936.

In this species the embryo nearly always develops in the right horn of the uterus. A single embryo was found in the right horn of each of 300 pregnant females examined and in only 1 individual was it in the left horn.

Females of this species apparently reach maturity during their first year, as shown by a banded individual. Seventy-six young *Tadarida* but a few days old were banded in this colony June 7, 1929. On April 11, 1930, a banded female which contained an embryo, was taken. The band of this individual is greatly worn and the number is illegible. The teeth also are greatly worn, presumably due largely to their use in trying to remove the band, for I have seen some of these banded *Tadarida* bite the bands attached to the legs. There seems to be no reasonable doubt, however, that this is one of the young banded the previous June, for under date of July 9, 1931, Frederick C. Lincoln of the Bureau of Biological Survey, from which source the bands were secured, wrote me that no one else to his knowledge had banded any free-tailed bats in the eastern United States. For these reasons it seems evident that female *Tadarida cynocephala* are mature their first year, at the age of about 9 months.

A periodic sexual development is known to occur annually in the males of some species of bats in which the time of ovulation is probably well defined. An extensive account of the reproductive cycle of males of several species of bats of western Europe was given by Courrier (1927). He had many specimens, taken at various times of the year, of *Vesperugo pipistrellus* (= *Pipistrellus pipistrellus*, Miller, 1912), *Miniopterus schreibersii* and *Vesperugo serotinus* (= *Eptesicus serotinus*, Miller, 1912) and less adequate series of

Vespertilio murinus (Schreber) (= *Myotis myotis*, Miller, 1912), *Vespertilio capaccinii* (= *Myotis capaccinii*, Miller, 1912), *Plecotus auritus*, *Rhinolophus ferrum-equinum*, and *R. hipposideros*.

He showed that spermatogenesis occurs from spring to autumn and that the spermatogenetic tissue is in a resting condition at other times of the year. He thus corrected the supposition of previous authors that spermatogenesis continues throughout winter, and added the information that living spermatozoa are stored in the epididymis of probably all of the species he studied with the exception of *Miniopterus schreïbersii*. In the case of the last named species he stated that spermatozoa are not abundantly present in the males after November, although a few were found in the male genital tract of April specimens.

Nakano (1928), without knowledge of Courrier's work, likewise found the sexual cycle of the males of the Japanese species *Vespertilio abramus* to be of the usual type described by Courrier. Nakano stated that spermatogenesis begins at the end of spring and is complete in October. From the end of October to June the seminiferous tubules are in repose, but spermatozoa are stored in the tail of the epididymis from October to May.

While a periodic sexual cycle occurs in the male *Tadarida cynocephala*, spermatozoa are not stored in the epididymis for long after they cease to be produced in the testis, and the season when spermatogenesis occurs is different from that of the species of bats studied by Courrier and Nakano. In figure 4, the presence or absence of spermatozoa in the testis or epididymis of specimens taken at various times of the year is indicated together with the weight of these organs after having been preserved in 10 per cent formalin.

The sections show that spermatozoa are abundantly present in the testis and epididymis of adult males taken in February and March, but none are present in these organs later in the year than April 18. From May to August, the seminiferous tubules are in a resting condition and no spermatozoa are stored in the epididymis. A proliferation of the spermatogenetic tissue takes place in September, resulting in an increase in the size of the seminiferous tubules and the testis as a whole. Spermatogenesis continues throughout the winter but no spermatozoa were found in specimens taken earlier in the winter than January 20. A few possibly mature spermatozoa are present in the testis of a specimen taken January 20, and another January 30, but no spermatozoa are present in the epididymis of these specimens.

It is thus evident that the male *Tadarida cynocephala* is sexually active only from early February to the middle of April, and that spermatozoa are not stored in the epididymis of this species for an unusually long time.

Courrier and Nakano each showed that the accessory sex glands of the species of bats that they studied are well developed in males in which spermatozoa are present. That similar conditions exist in *Tadarida cynocephala* is shown by measurements of the length of the prostate gland, taken along

the mid-ventral line, as recorded in figure 5. These measurements were made on the same specimens in which the testis was studied. A comparison of figures 4 and 5 shows that the prostate gland is enlarged only when spermatozoa are present and that the enlargement of this gland occurs somewhat later than that of the testis. According to Courrier, the interstitial tissue of the testis is responsible for the regulation of the development of the accessory sex glands.

Males of *Tadarida cynocephala* in which the testes are small and contain no spermatozoa were taken in all months of the year. The prostate glands of the same specimens are also small. Of such individuals taken in the first 3 months of the year, the teeth are not greatly worn. For this reason it seems probable that the sexually immature males of this species taken during the breeding season are young. Probably they become mature in their second year.

The breeding habits of *Tadarida cynocephala* are apparently much like those of *Tadarida mexicana*, for Hartman (1933, p. 191) stated that Cuyler and himself found that the breeding season of the latter species occurs only in spring, the organs of both sexes being in a resting stage at other seasons.

Parturition in captive specimens of *Tadarida cynocephala* was observed in its entirety in 2 cases, but only one can be considered as normal. The other bat was weak and the young was dead when born. The last stages of parturition were observed in another captive. The observations of the birth of a normal young one were made June 30, 1931. The mother had been hanging head down from the side of the cage in the normal manner when she became restless and uttered a few notes, as this species usually does when irritated. It was then noticed that the fetus had changed from the transverse to the longitudinal position since the previous observation made 15 minutes earlier. A few minutes later the young appeared, rear end first, only 60 seconds elapsing from its first appearance until all but the head had emerged. During the brief pause, about 30 seconds, before the head emerged, the amnion was scratched to shreds by the claws of the mother's feet. The tail and feet of the young became extended, but it did not move at this time. The posture of the mother during parturition was not much different from that usually assumed by this species, and the flight membranes were not used to receive the young. As a result, immediately after birth, the young was suspended only by the umbilical cord. The mother seemed to ignore it completely and it was about 15 minutes before the young one found a nipple and began to nurse.

The placenta appeared about 2 hours after the birth of the young. At this time the mother tried to crawl away from the young one, which had hung up on the side of the cage beside its parent. The young, which was still attached by the cord, made no attempt to follow. After several such movements on the part of the mother, the placenta emerged. She went to

the opposite side of the cage and remained away from the young one until sundown. The placenta remained attached to the young by the cord for 2 days, when the dried cord broke close to the body.

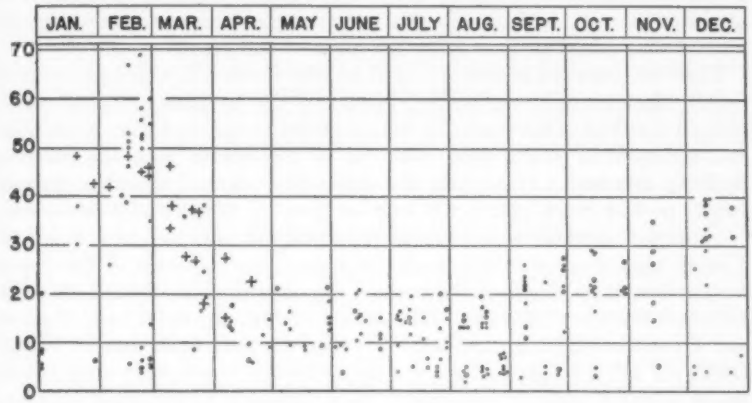


FIG. 4. Weight, in milligrams, of the testis of *Tadarida cynocephala*. Dots indicate organs which were not examined for the presence or absence of spermatozoa. Crosses indicate those in which spermatozoa were found to be present, and circles, those in which no spermatozoa could be found.

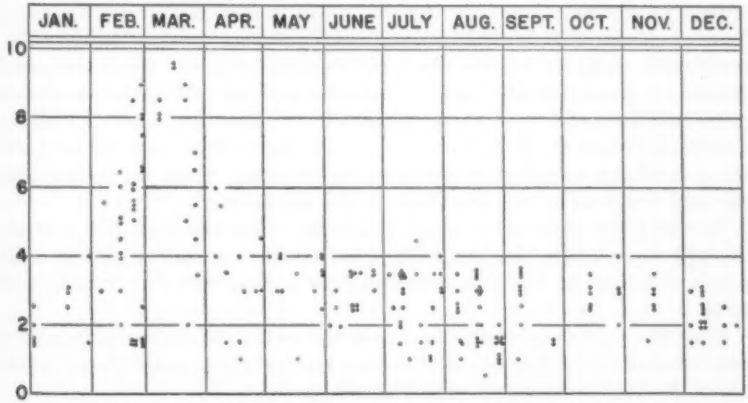


FIG. 5. Length, in millimeters, of the prostate gland of *Tadarida cynocephala*

Observations of the last part of parturition in another captive were made June 24, 1931. At 12:15 P. M. the fetus was in a transverse position, but when next observed at 12:40 all but the head of the young had emerged.

The amnion was torn and the young seemed much more vigorous than in the case of the one previously described. Its feet had found support on the side of the cage before parturition was complete and within 5 minutes after birth it was nursing, although, as in the former case, the mother had paid it no attention since its arrival. In this case the placenta was removed as described above half an hour after the birth of the young.

That the placenta is not devoured by the mother in this species, as is usually the case with mammals, is shown by the fact that the placenta remained attached to the young by the cord from 8 hours to 2 days in captives, and hundreds of young were observed in the colony with the placenta similarly attached. Apparently the time when the cord is broken depends largely on how much agitation it receives from the young and its associates.

Published information concerning parturition in bats has been found for 5 other species, all of which, so far as known, are members of the family Vespertilionidae. Birth of the noctule was described by Daniell (1834, p. 131) and Whitaker (1905, p. 327). Jobert ((1872, pp. 138–9) and Rollinat and Trouessart (1896, pp. 230–231) described the birth of the murin. Blake (1885, pp. 449–450) gave an account of parturition in a captive West Indian bat of unknown identity. He stated his intention of forwarding a couple of preserved specimens to the Science and Art Museum, Dublin. However, at my request, Dr. P. O'Connor, Keeper of the Natural History Division of the National Museum of Ireland, generously made a search for these specimens but without success. Parturition in *Myotis austroriparius* was described by Sherman (1930, pp. 496–497), and that of *Myotis lucifugus lucifugus* by Mohr (1933, pp. 52). From these accounts it seems that the vespertilionids regularly use the flight membranes, especially the interfemoral membrane, to receive the young at the time of birth. Also, the placenta is eaten and the cord broken by the mother in 4 of these 5 species. In *Myotis l. lucifugus*, however, Mohr stated that in several cases at least the cord was not severed but remained attached to the placenta, which dried, and that the cord broke off at the umbilicus on the second day.

The small size of the interfemoral membrane of the Molossidae in comparison with its extent in the Vespertilionidae furnishes a ready explanation for a lack of its use in *Tadarida cynocephala* as a receptacle for the young at birth.

From the evidence available, failure of the mother to devour the placenta and to break the cord may probably best be considered as specific peculiarities of *Tadarida cynocephala* and *Myotis l. lucifugus*.

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THE BURROWS AND FOOD OF THE PRAIRIE POCKET MOUSE

By W. Frank Blair

During the course of field work in Rogers County, Oklahoma, in the winter of 1933 and the summers of 1935 and 1936, numerous burrows of *Perognathus hispidus maximus* were excavated and examined. A few records were kept of food found in the cheek pouches of individuals caught in snap traps. From these two sources I have assembled the data presented herewith.

I am indebted to O. W. Letson for his kind assistance in the identification of many of the plants mentioned in this study. Many of the food materials were determined by A. C. Martin of the U. S. Biological Survey. The insect material was identified by I. J. Cantrall. I wish also to thank Lee R. Dice and W. H. Burt for critically reading the manuscript.

Burrows.—In this area prairie pocket mice were found only on rocky, uncultivated prairie. Within this major habitat two factors seemed to be most important in determining the location of their burrows. Every burrow examined was located, at least partially, beneath a limestone fragment. These limestone slabs were found in the prairie habitats having thin soil and scanty vegetation and in the areas characterized by deeper soil and denser vegetation. Pocket mice occurred beneath them in both types of habitat, but more mice were found living in the more densely vegetated area. This habitat is characterized by such woody plants as smooth sumac (*Rhus glabra*) and persimmon sprouts (*Diospyros virginiana*). Typical grasses are side-oats grama (*Bouteloua curtipendula*), silver beardgrass (*Andropogon saccharoides*), buffalo grass (*Buchloe dactyloides*), and windmill grass (*Chloris verticillata*). Other characteristic plants are prickly pear (*Opuntia humifusa* and *Opuntia tortispina*), nettle (*Tragia nepetaefolia*), and blue false indigo (*Baptisia australis*).

Several observations on the burrows were made. I have found, as did Bailey (North Amer. Fauna, no. 25, pp. 135–137, 1905) with the subspecies *hispidus*, that mounds of earth resembling pocket gopher mounds generally are thrown out near the entrances, and that usually there is more than one entrance. Most of the burrows examined had two or three entrances, but a few had only one. The entrances generally were plugged from within during the day, but this was not always the case. One system of burrows never contained more than a single individual.

There is a rough correlation between the age of the mouse and the extent and complexity of its burrow. The burrow of an immature individual generally is an unbranched tunnel beneath a limestone slab. The bottom surface of the rock forms the roof of the tunnel. Unconsumed food is scattered about the tunnel. Older individuals occupy much more elaborate systems of burrows. The tunnels are branched considerably and may pro-

ject under other rocks or into surrounding soil. Usually there is a store chamber containing food. A characteristic feature of the burrow is a short side tunnel branching at a right angle and often enlarged at the end to form a chamber. Generally this is located near the main entrance. When the burrow is molested the mouse enters the side tunnel and plugs it with dirt from within, often escaping detection in this way.

Stores.—While most of the burrows held some food, a few of those examined contained rather large stores of food materials. The store chamber of a burrow opened on July 23, 1936, contained 31.2 grams of carefully hulled seeds of *Gaillardia pulchella*. A burrow examined on November 18, 1933, had a store chamber with about one-fourth pint of *Bumelia lanuginosa* seeds. One excavated on July 14, 1936, contained 4.1 grams of seeds of *Fagopyrum esculentum*, with which were mixed a few spikelets of *Hordeum pusillum*. From these observations it seems that the storing of food is not limited to any particular season of the year. Rather does it appear that food is stored whenever available.

Food.—The cheek pouches of a pocket mouse trapped June 26, 1936, were stuffed with hulled seeds of *Gaillardia pulchella*. A mouse trapped July 3, 1936, had a small unidentified bulb in one of its cheek pouches. Other food records were obtained by the examination of burrows.

Table 1 presents the list of food items found in 18 burrows, and indicates the number of burrows in which each was found. In many cases the evidence of the presence of a particular plant was derived from remnants of fruit bodies of which the edible portion already had been utilized. Thus the plant materials found at any one time represented an accumulation over a period of time, and therefore did not indicate that all were being used at the time of examination.

General observations lead me to believe that most of the more important foods of this pocket mouse are included in the table. It does not include records for late winter and spring, but observations on which no notes were kept indicate that the prickly pear is the most important food plant during this period. In this study no attempt has been made to distinguish between the two species of prickly pear occurring in the region.

By showing the frequency of occurrence of the various food items in pocket mouse burrows, the preceding table indicates which foods probably are of the most importance in the diet of the prairie pocket mouse. Plant seeds greatly exceed insect materials both in the number of species recorded and in the total number of occurrences. The 30 plants identified have a total occurrence of 86, while the insect material, represented by 6 species, has a total occurrence of 10. On the basis of frequency as the criterion of importance, *Gaillardia pulchella* (present in 8 of the 18 burrows), and *Opuntia* (present in 7), rank as the most important foods of the prairie pocket mouse. The 6 species following them in the table probably are scarcely less important.

The insect remains found in the burrows indicate that some food of this type is a regular part of the diet. Live grasshoppers of the genus *Melanoplus* were killed and eaten by captive mice. The mice seemed to prefer the head, abdomen and legs, as those parts were eaten first.

Four of the 18 burrows contained dry fecal pellets of the Oklahoma cottontail, *Sylvilagus floridanus alacer*. This species is common in the pocket

TABLE 1

List of food materials found in the examination of 18 burrows between June 27 and December 9, with the number of burrows in which each occurred

PLANT MATERIAL	NO. OF BURROWS	PLANT MATERIAL	NO. OF BURROWS
Gaillardia pulchella	8	*Chaerophyllum texanum*	2
Opuntia	7	*Sanguisorba annua*	2
Oenothera flava	6	*Malvastrum angustum*	2
Callirhoe alcaeoides	6	*Carex* sp.	1
Fagopyrum esculentum	5	*Sedum pulchellum*	1
Tragia nepetaefolia	5	*Astragalus nuttallianus*	1
Unidentified bulb	5	Legume pods (possibly *Galactia*)	1
Hordeum pusillum	4	*Sporobolus* sp.	1
Prunus angustifolia	4	*Gutierrezia sphaerocephala*	1
Monarda citriodora	3	*Bumelia lanuginosa*	1
Carya pecan	3	*Vicia* sp.	1
Croton monanthogynus	3	*Lathyrus pusillus*	1
Unidentified legume	2	*Oxalis* sp.	1
Bouteloua curtipendula	2	*Lesquerella* sp. ?	1
Andropogon saccharoides	2		
Diospyros virginiana	2	Total occurrences of plant materials	86

INSECT MATERIAL	NO. OF BURROWS
Melanoplus sp.	3
Lepidopteran pupa case	3
Carabid beetle	2
Ceratopogon larvae	1
Dermestidae	1
Total occurrences of insect materials	10

MISCELLANEOUS MATERIAL	NO. OF BURROWS
Fecal pellets of *Sylvilagus floridanus alacer*	4

mouse habitats, and the pellets are widely scattered in the area. Evidently the pellets are eaten by the mice, as several of them showed signs of having been gnawed.

It appears from a survey of the plants of the immediate and surrounding habitats that availability is the most important factor in the selection of food. With one exception—pecan nuts, identified from three burrows—the

food plants were those of the habitat in which the burrows were found. The nearest pecan trees were approximately 500 yards from two burrows in which nuts were found, and one-half mile from the other. To reach the pecan trees the mice would have to cross a narrow belt of oak-hickory forest and enter a wooded ravine at the bottom of which the trees were found. It is possible of course, that the nuts were dropped by squirrels near the forest boundary and thus became available to the pocket mice. Of the other food plants identified, almost all were among the abundant species of the habitat at some season of the year. When plum pits were found they were in burrows in or near plum thickets. As with the plants, the insects eaten were of species readily available to the mice.

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CONE-PILING BY MICHIGAN RED SQUIRRELS

By Lee E. Yeager

In November, 1935, the cone-piling and related habits of *Sciurus hudsonicus loquax* were studied in three Norway spruce stands in Saginaw Forest, one of the experiment stations of the School of Forestry and Conservation, three miles west of Ann Arbor, Michigan. These stands are designated as Blocks V-3, II-1a-b, and IV-7, and contain, respectively, 2.21, 1.68, and 1.03 acres. Trees, in the same order, are 26, 33, and 23 years old and average about 5 inches D.B.H. and 30 feet in height. The stands are completely closed and natural pruning of the lowest branches is well begun. The blocks, in position, form the points of a slender arrowhead, the longest distance between them being a little more than one-eighth mile. Open fields and various stands of hardwoods and conifers surround the three Norway spruce areas.

The number and size of cone-caches by blocks was as follows:

Block	Cache No.	Bushels of cones		Type of cache		Site of cache	Covering of cache
		In Cache	Tot. for Block	Scattered	Compact		
V-3	1	7.0	16.0	*		Park between trees	None
	2	1.5			*	Base of tree	None
	3	4.0			*	Base of tree	Moss
	4	3.5			*	3 ft. of tree	None
II-1a-b	5	5.5	10.0		*	Head of small gully	None
	6	4.5			*	Edge of brush pile	Moss
IV-7	7	3.0	6.4		*	Under old pine log	Log?
	8	3.4			*	2 ft. of tree	None
Total amount of cones piled.....			32.4 bu.	1	7		

The single scattered cache differed from the compact caches in that the bulk of the cones composing it were scattered over an area about 15 feet square, in a small park-like space between the trees. Very few of the cones were within three or four feet of the base of a tree, most of them being in three concentration points of 1.3, 1.4, and 1.6 bushels. All compact caches were piled cleanly, each being near the base of a Norway spruce tree, a log, a pile of brush, or in the shelter of a shallow, straw-filled gully.

Two of the compact caches were partly covered with moss, which was green and evidently had been gathered from the area immediately adjacent to the cache. A visit three weeks later showed that more moss had been added to the covering of these cones. The site of the log-covered cache may or may not have been purposely chosen.

In an estimate of the unpiled cones on Block V-3, it was found that 17.5 bushels, or slightly over 51 per cent, were widely scattered over the area. Very few scattered cones were found around the caches. The other two spruce areas were not sampled systematically, but appeared to have about the same percentage of unpiled cones.

Careful study of 100 cones picked at random from cache no. 1 showed that 20 per cent bore evidence of having been chewed off the branches, 62 per cent bore ample evidence of having been pulled, chewed, torn, or otherwise forcibly removed from the trees, and 18 per cent appeared to have dropped in the natural manner. In 12 per cent of these cones, scales had been cut or eaten from the base, and in 88 per cent no such removal of scales had occurred. A careful survey of the trees surrounding cache no. 1 showed that almost all of the cones had been removed in this vicinity, the percentage removed being somewhat higher here than around the other caches, and distinctly higher than at some distance away from the caches.

Very few red squirrel nests were found in trees on the three Norway spruce areas, but ground dens were found within a few feet of caches no. 2, 3, 4, 5, 7, and 8. The den or dens at no. 4 had three entrances, and the dens at caches no. 3, 5, 7, and 8 had two entrances. Entrances to the same den were never more than 6 feet apart. All dens were verified as being used by red squirrels by tracks in light snow leading in and out, or by seeing an animal leaving or entering a den.

The number of red squirrels on the areas was not determined. In December, 1935, three squirrels were taken in a live trap at cache no. 5 in the course of three days. Such observations as were made clearly indicated that the populations in the vicinity of the Norway spruce stands were heavier than in the adjacent ponderosa pine, Norway pine, or hard wood stands. Careful investigation showed that the cone crops in the two pine stands were light. The crop in the spruce stands was unusually heavy.

In an attempt to obtain some idea of the amount of food eaten per squirrel per day, there was made in the laboratory a study of one measured bushel

of cones taken at random from cache no. 1. This was done under the direction of Dr. E. C. O'Roke of the School of Forestry and Conservation of the University of Michgan. The following data were obtained:

1. Number of cones per bushel	325
2. Weight of one bushel of cones, pounds	37.5
3. Average number of seed per cone	285
4. Average number of scales per cone	155
5. Number of seed good, per cent	82.7
6. Average weight of good seed per cone, grams	1.897
7. Weight of good clean seed per bushel of cones, grams	616.52

In a study of 6 stomachs of squirrels taken late in November from the spruce stands, it was found that the stomachs and their contents averaged 6.1 grams in weight, and that the dried contents of the 6 stomachs averaged 1.7 grams. Hatt (The Red Squirrel: Its Life History and Habits, Roosevelt Wild Life Annals, vol. 2, no. 1, 1929) found that the average weight of 24 red squirrel stomachs was 5.8 grams. He did not give the weight of the dried contents of the stomach. He stated that "the food of the red squirrel is so thoroughly chewed before being swallowed that it is usually very difficult to determine the composition of the finely ground mass." This was found to be true, but the husks of spruce seed were unmistakably identified in the Michigan case.

Assuming that red squirrels eat two grams of spruce seed per day, it was calculated that the 32.4 bushels of cached cones would provide enough food to carry a population of 65 squirrels through the 5 coldest months of winter (November–March inclusive). The calculation is as follows:

$$\frac{32.4 \times 616.52}{152\,(\text{days}) \times 2} = 65.7 \text{ or } 65 \text{ red squirrels}$$

The time of day marking the greatest cone-piling activity was not accurately determined. Observation showed that the squirrels are erratic workers, spending considerably more time eating cones, sitting in trees or on the caches, or playing in the trees or on the ground in the vicinity of the caches, than in actual cone-piling. During the colder days of November the animals spent a great deal of time inside their underground dens. Feeding, on cold days, was usually on the cache itself, or just above the ground on one of the many near-by dead spruce branches. There was strong evidence that cones were carried underground. Cone-piling appeared to be a den or community activity, although the difference, if any, in the amount of work done by individuals was not determined.

It is possible to place a value on the cone-piling habit of red squirrels in localities where cones can be sold. The value per bushel, local delivery, ranges between 1 and 1.50 dollars. In gathering cones, removal from the tree is the most expensive operation, the cost being at least half the sale

price. The squirrels, therefore, may be credited this amount for each bushel of salable cones cut off the trees.

In a bog swamp known as Mud Lake, about 12 miles northwest of Ann Arbor, red squirrels are known to frequent the black spruce-tamarack tracts during the winter, living largely in underground dens. These dens usually are located in or near the larger clumps of black spruce, almost always have more than one entrance, and small caches of black spruce cones with abundant evidence of feeding are commonly found on the surface litter in the immediate den area. The winter dens of the red squirrels in Mud Lake swamp closely resemble those of the animals in the Adirondack region, as reported by Hatt (1929).

In the survey of Block V-3, it was found that the yield of cones was not uniform over the area, and that the caches were generally located near or under the heaviest-bearing trees. The 1936 cone crop over the three spruce areas was very poor, and a survey of the stands disclosed no fresh caches nor evidence of cone-piling, and a very low red squirrel population. It seems reasonable, therefore, to conclude that the location of caches is not determined by the age of the stands, the density of the trees, nor the ground cover, but by the presence of food on the area.

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NOTES ON YOUNG SKUNKS IN CAPTIVITY

By LeRoy C. Stegeman

The skunk (*Mephitis nigra*) is one of our most important fur-bearers, and skunk farming offers fair promise of becoming a profitable enterprise. Few observations have been made concerning the early development of this species, and therefore the following information, secured from several litters of young skunks raised in captivity, may be worthy of note. Several of the animals included in this study were from wild-caught pregnant females, others from pen-bred animals, and still others were wild-caught young.

Observations were made and carefully recorded daily throughout the summers of 1931 and 1932. In 1931, the observations were based upon two litters born in captivity, and in 1932, on young from at least 9 different litters. The number of young animals under observation during 1932 was as follows: June 4 to June 13, 3 animals; June 13 to June 16, 6 animals; June 16 to June 18, 7 animals; June 18 to August 5, 10 animals; August 5 to August 25, 13 animals; August 25 to August 31, 11 animals. Particular attention was given to the development of the teeth and to the rate of growth.

The occurrences during the period immediately preceding and following

birth are of the utmost importance to the fur farmer, since it is during this period that the annual increment is largely determined. It therefore will be worth while to recount the observations made on the first two litters. The approaching birth of the young skunks was first indicated by an unusual amount of restlessness on the part of the two females concerned. They were seen walking restlessly about the pens during the day time, which was unusual. When additional nesting material was placed in the yards, it was promptly carried into the nest boxes. More was added and the animals continued to carry in this material until, on examining the boxes, they were found to be nearly full. Shaw (New York State Mus. Handb. no. 4, pp. 1–92, 1928) noted this same behavior on the part of the female observed by him in his study. That night both females came for their food as usual, and everything seemed to be normal. The following day nothing was seen of the skunks and that night only the larger of the two came out to feed. The next morning, May 10, when the cover of the nest box of the smaller female was lifted, she looked up but showed no inclination to leave the nest as was her usual habit. She arose to her feet, however, and as she did so the little ones began to utter hoarse, high-pitched, vibrating squeaks. The family was then left undisturbed and the number of young was not determined. The larger female continued her normal behavior until the night of May 12, when she failed to appear for food. She was not seen out of the nest box the following day nor the following evening (May 13) at feeding time; but it was noted that she had come out to feed some time later that night. When the pen was visited later the same evening, the young ones could be heard uttering the previously described sound as the mother apparently shifted her position in the nest.

The day following the birth of the first litter (May 11) the cover to the nest box was carefully lifted. The mother hurriedly left the nest and rushed into the outer pen. She then seemed anxious to return but was afraid to do so. Six young were found in the nest, but two of them, evidently less than 24 hours old, were dead, apparently having suffered bites through the abdomen. These observations were quickly made, and the family thereupon was left undisturbed for the remainder of the day. The following day, when the mother was out feeding, the nest was again inspected, and one more young was found dead and another dying. When the nest box was opened the young began uttering their characteristic cries, and the mother at once became restless and appeared anxious to return to the nest, but was too shy. The same evening the fourth little skunk died. Neither of these last two young skunks showed signs of having been bitten, but one of them appeared to have been trampled or smothered to death. There were no further casualties in this litter.

No observations were attempted on the second litter, born May 13, until the mother had left her nest on the second night. A glance into the box

then revealed six young ones, three of them dead. These young made the same kind of cries heard from the first litter. The nest was then left undisturbed for another two days, and at this time two more young were found dead. From their state of development and general appearance they evidently had died shortly after the previous inspection of the nest. There were no outward signs as to the possible cause of death, but they may have been trampled or smothered. The remaining young seemed to be normal and healthy but died on the twelfth day.

In talking with several persons who have raised skunks in captivity, I found their experiences to be quite similar. It is agreed by all that at the time of birth and for at least a week thereafter the animals should be kept as free from excitement as possible and not disturbed in any way. The nesting boxes, particularly, should not be disturbed. After the young have become large enough to leave the nesting box of their own accord, the critical period seems to be past.

In the wild condition the mother usually is protected from noises and disturbances in her chosen den. With the exception of the male skunk there are probably few enemies of the young that can gain entrance while the mother is on guard. Occasionally, however, males are known to enter a den and kill the young, perhaps even their own offspring. This, of course, must be the exception rather than the rule, or the race would soon end. It is known that in nature the mother enjoys comparative solitude during and after the birth of the young.

Regarding this Seton (Lives of Game Animals, vol. 2, p. 353, 1929) said: "In captivity there is a great danger of the mother devouring her young when first they arrive. In a state of nature there is no reason to believe that the young run any such risk. Whatever the impulse—fear, nervousness, fever, or thirst—Dame Nature has anticipated this stress and provided a remedy, from which we may argue that we should, as far as possible, repeat natural conditions in the zoo if we are to avoid this disaster. Once the critical period is passed and the mother love fully aroused by her squirming, helpless brood, her devotion is ideal."

Growth and development is a gradual and continuous process and the ages, or growth stages, herein described are taken from daily observations to illustrate the progress of their development.

Young at birth.—The young skunk when born is a blind, much wrinkled, large-headed, pink-skinned individual, covered with a very thin coat of short fine hair. The color pattern is plainly discernible at birth, the white appearing much lighter than the rest of the animal. The white stripe on the face, the nuchal patch, and the two lateral stripes are clearly defined. The extent of the white areas is more precisely determined at this age than in the adult. The head has the typical mustelid form and looks much too large for the rest of the animal. The ears are closed and flattened tightly against the

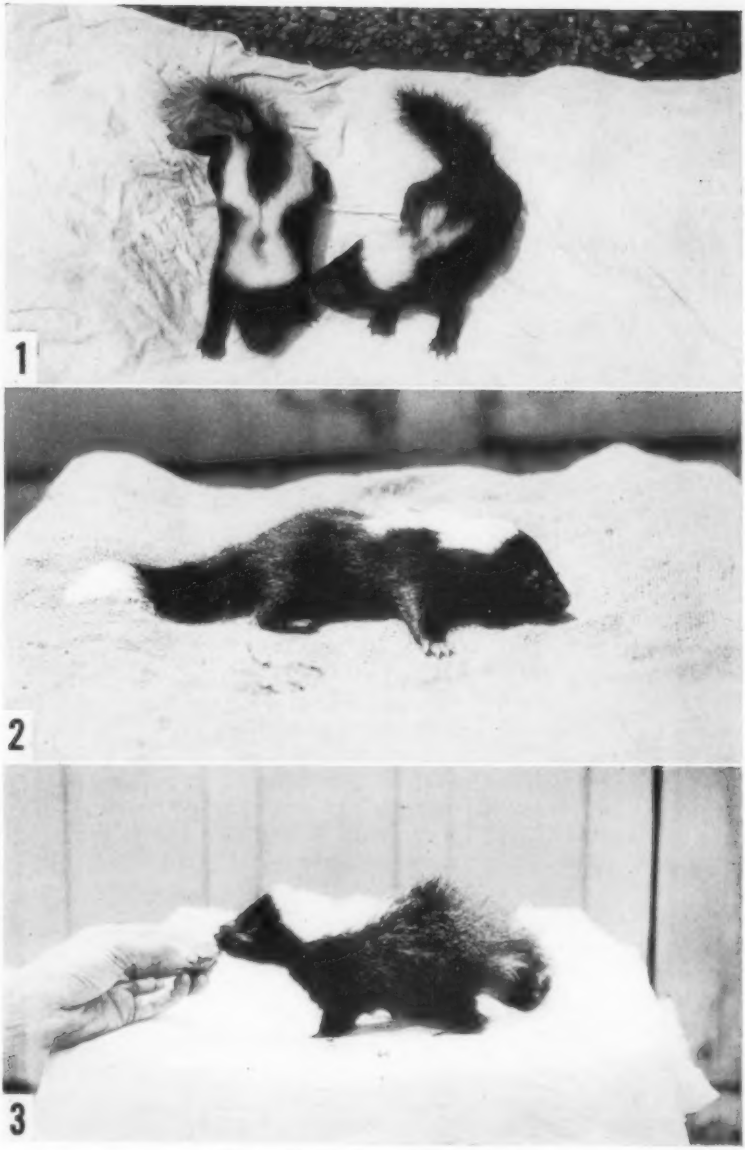


FIG. 1. Young skunks 26 days old
FIG. 2. At age of 36 days
FIG. 3. Young skunk 47 days old

head, the claws on both front and hind feet are well developed and the sex can easily be told.

Young two days old.—The wrinkled condition has nearly disappeared at this age, and the entire animal is considerably darker in appearance. The hair is considerably longer and the skin also is darker, a deep gray except for the white areas, which still are pink. The body now is plumper, and the head seems less out of proportion. At this age the little skunk is able to keep itself right-side-up and can roll over if placed on its back. It seems more to be annoyed by things about it. Its cry is somewhat louder, but still has the same characteristic sound.

Young seven days old.—The appearance of the young at this age is not greatly different from that of the two-day stage, but they are able to handle themselves better. They now do a considerable amount of kicking and rolling, although no definite result seems to be accomplished thereby. The hair is somewhat longer, the skin is more pigmented, and the white areas appear lighter in color.

Young twelve days old.—At this age the young are beginning to fill out and appear more sturdy. The hair is thicker, and about one-eighth inch in length. The skin appears thicker and darker in color, except for the white areas, which now appear whiter. The eyes and ears still are tightly closed. The claws are much better developed, on the front feet being nearly twice as long as those on the hind feet. They are much sharper than at birth.

Young twenty-one days old.—The hair has grown considerably in length and increased in density until the young look much more like adult skunks. The luster of the fur is very evident. The eyes are just beginning to open, and they seem more sensitive to things about them. They become more excited, the hair on their tails becoming erect, and they try with greater success to hide themselves by clustering together. They now can definitely crawl, and when separated, manage to find each other rather quickly. The male, as from the first, seems decidedly stronger and slightly larger than the female. They do not cry so frequently, and the male is heard more often than the female.

Young twenty-six days old.—On being disturbed, the young now try to bury themselves in the nest litter. They can raise their forequarters, and even arch their backs and assume the typical skunk posture when on guard, except that their hind legs are too weak to support them steadily, so that they settle back upon their haunches. Their tails are well haired and when this hair is erect they look quite "business-like." Figure 1 shows their development at this age. The difference in the amount of white on the two animals may be noted. The white hair seems to be slightly longer than the black, and this tends to increase the apparent size of the male, which has the more white. The greater amount of long white hair in the tail of the male makes it appear much the longer, although the tails of both sexes

measure the same length. The prominence of the claws on the fore feet and the relatively large heads may be noted. The ears also are beginning to open. The state of development of both the eye and the ear is best shown in the female in figure 1. The mother has overcome some of her shyness, and when one of the young is being examined she takes the other to the outer pen, unless prevented. She picks it up by the skin of the neck, in the same manner that a cat carries a kitten.

Young thirty days old.—The female young is much less excitable than the male. She does not utter a sound nor protest when picked up and weighed. The male immediately assumes the defensive attitude, and when picked up, utters its characteristic cry. The female weighs 198 grams, and the male 226 grams, a difference of 28 grams or approximately one ounce. Both eyes and ears are open at this stage, and the animals handle themselves much like young kittens. The young were not agitated for the purpose of testing their ability to emit musk at this age, but Shaw (1928) stated that in his study the musk smell first was distinctly noticed at the age of 28 days.

Young thirty-six days old.—A remarkable improvement in the ability to handle themselves is noticed at this time. They walk about freely and quite rapidly. They still rest their bodies on the ground when standing, and they brace themselves nearly as much as before (see figure 2). Their fur has a very fine luster. They keep themselves very clean, and the white makes a very striking contrast with the jet black. The development of the face and the shape of the head is clearly seen in figure 2, which shows the female. Both young are now tamer. This probably is due to the repeated handling incident to weighing and measuring. The weight of the female is 241, and of the male, 297 grams. The incisor teeth show plainly through the gums, but have not yet erupted. Despite this fact they show considerable interest in solid foods and seem to eat some of it without difficulty.

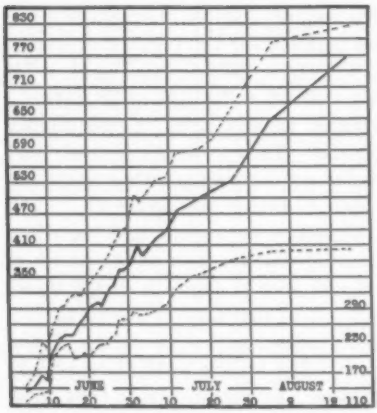
Young thirty-nine days old.—On June 21, at the age of 39 days, the incisors of both young are through the gums. They are very sharp, and each has three fine cusps. When carried by the mother into the outer pen, they crawl around cautiously, investigating everything. When the mother returns to the nest the young follow her.

Young forty days old.—The second and third premolars of both upper and lower jaws are just pricking through, and they are almost as sharp as needles. Both animals are in the same stage of tooth development. The mother took the little male into the pen, and he returned to the pen twice after she had carried him back into the nest. He apparently objects to being carried, judging from his characteristic cries.

Young forty-one days old.—The young skunks were out playing in the evening when their feeding time arrived. They held their tails erect and hopped about stiff-legged, bumping against their mother as though trying to coax

her to play with them. The mother had discovered my presence, however, and was intently watching me. The young ran in and out of the pen freely, reminding one of a pair of kittens of corresponding age. When approached, they ran into the nesting box with their tails held high in the air. When the nesting box was opened, they moved about with their backs arched and their tails held erect, bristling in the typical defensive manner. It was necessary to shut the door of the pen to keep the mother from carrying them outside. They are growing very fast and the fur is much longer.

Young forty-seven days old.—Figure 3 shows the development at 47 days of age. Notice the ability to support the body off the ground. The legs are much stronger and the youngsters travel about the pen with ease.



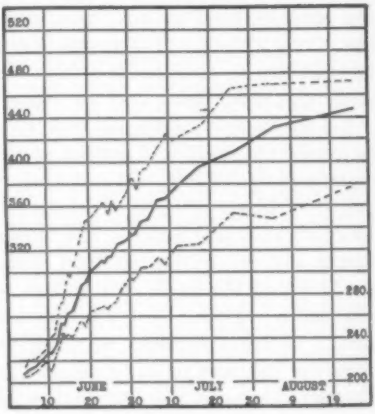


FIG. 4. Total weight in grams (left). FIG. 5. Total length in millimeters (right).

Young fifty-one days old.—The lower canines of both animals were through the gums but the upper canines were still lacking. All the teeth were needle sharp, and small though the animals were, they could give one quite a pinch. The young ones seemed as greedy for meat as was the mother, and though their teeth were small, they managed meat successfully. When the young ones were playing in the yard they reacted promptly to the behavior of the mother. If she showed alarm and started toward the box, both little ones did likewise, with their tails erect, proceeding by little stiff-legged jumps, and with an attitude of defiance.

The characteristic odor was noticed for the first time at this age, but it was faint. They probably had been fighting or quarreling over their food, or pinched one another too strongly in play. They were inclined to quarrel a great deal over their food, uttering their high pitched, complaining cries,

which might be described as a cross between a squeal and a purr. It had a vibrating quality, but was much harsher and more complaining in character than the earlier sound. They used the same method of defense as the adults, namely, placing their hind quarters against their opponent and shoving. They even defended their food against seizure by their mother. The latter, however, after an apparent scrutiny of the morsel, usually let them have it. When the quarrel over food became severe there was the unmistakable odor of the musk.

The pens were located under a cherry tree and the fallen fruit was eaten as fast as it dropped into the pen. They dug at the cherry with the front feet, much as a dog would dig at a hole, and their claws tore it to shreds. They then licked up the juice and ate the fleshy parts. The little skunks were as adept at this as was the mother. They now ate anything that she ate.

When fresh grass was placed in the pen the little ones poked their noses into it and pawed it around as though searching for insects. They played with a number of plantain leaves among the grass and carried some of them into the nesting box. They ate a considerable amount of the green grass and always carried the rest of it into the nesting box.

When approached, the mother grabbed the young by the skin of the neck and dragged them into the nesting box.

Young fifty-three days old.—July 5. The upper canines had erupted in both animals.

Tooth development.—The teeth of the young skunks observed had a definite order of appearance, which usually is true in all mammals. In the cases observed, those in the lower jaw preceded the corresponding ones of the upper jaw. The order of appearance and the approximate ages at which they came was as follows: lower incisors, 34 to 39 days; upper incisors, 35 to 39 days; second and third premolars (lower), 40 to 41 days; lower canines, 43 to 45 days; second and third premolars (upper), 40 to 44 days; first premolar (lower), 43 to 46 days; upper canines, 45 to 50 days; first premolar (upper), 45 to 50 days.

With a larger number of animals under observation there would no doubt be a greater variation in this table. The order of arrival, however, seems well established.

All of the teeth were at first very sharp and erupted rapidly once the gums began to break. They could be seen very plainly through the gums for several days before they actually pierced the membrane. The incisor teeth were distinctly lobed; the premolars very pointed and sharp, appearing almost like the tip of a knife blade. Doubtless food that requires considerable chewing influences the time of appearance of the teeth.

Growth curves.—Curves were plotted to show the growth and development of the young between the ages of 2 and about 12 weeks. The lengths were

carefully measured with a steel tape graduated in millimeters, and the weights were taken on a balance sensitive to one-tenth gram. All measurements were made at the pens, and therefore they fluctuated more than would have been the case under the controlled conditions of the laboratory. The pens were located at the edge of the city on a vacant lot and were subject to the usual traffic noises of busy streets, and also to the activities of the curious children of the neighborhood. These factors were somewhat reflected in the nervousness and excitability of the young skunks on various occasions. Most of the time they submitted quite peaceably to the gentle and slow manipulations necessary to secure the measurements, and the relaxation seemed quite uniform. At other times they were very excitable and resisted all attempts to measure them. This accounts in part for the irregularity of the curves. The mother skunks were taken in the wild within two weeks of the time the young were born. During that interval they were well fed and each animal seemed to be in very good physical condition. The newness of the surroundings and the artificial conditions under which the young were born were reflected in the large number of young that died in each litter.

The early development of the young should very closely parallel conditions in the wild state, for skunks adapt themselves to domestication very readily and the young are cared for at that time by the mother. The later development was affected by several factors: abnormal environment, food and sanitary conditions, as well as close confinement and excessive changes of temperature. The development and size of the captive young checked very closely with that of wild young taken and observed during the summer up to July 15, when the average age was about 8 weeks. From that time on the wild young taken in the field were somewhat larger and better developed. This condition could be overcome by giving proper attention to the factors mentioned, especially food, sanitation, and confinement, as has been proven on fur farms where skunks reach normal size and development.

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TAGGING STUDIES OF RED FOXES

By Paul L. Errington and R. M. Berry

During 1933 and 1934, the Iowa Fish and Game Commission had occasion to handle several hundred young red foxes (*Vulpes fulva*) taken from dens destroyed upon the complaint of farmers. In connection with cooperative wildlife studies carried on by the Commission and Iowa State College, many of these foxes were marked by deputy game wardens, by means of aluminum ear tags serially numbered and stamped with an understandable abbreviation of the name and address of the Commission. The tags remained well attached to the ears of the foxes and were of a type to be readily noticed by a hunter or trapper.

The data resulting from these tagging operations may be of some interest from the standpoint of natural history, but they have a particular bearing upon the practice of releasing foxes for sporting purposes on lands where they happen to be scarce or have been depleted by hunting. Fox hunting has a considerable following in Iowa, and the variable demand for animals for stocking purposes is in part supplied with young from other localities. The young may be kept for short or long periods before liberation, commonly at substantial distances (in some cases 100 miles or more) from the places where secured.

The intense feeling against foxes on most of the farms on which dens were dug out permitted the release of few young in the immediate neighborhood, after capture and tagging, even when the scientific desirability of the action was stressed. Accordingly only 5 tagged pups were liberated under conditions at all favorable to their being joined by their parents; 2 of one family in the vicinity of the original den, and 3 of another litter at a distance of two miles from the site of capture. Nothing further was heard of the 3 foxes released two miles away from the den, but the other 2 were trapped during the following winter. These were killed at distances of 16 and 18 miles from their natal locality, but in different directions.

It seems probable that, of all the young foxes tagged, these two were the only ones that succeeded in rejoining their parents. The survival of both until the time that they were trapped, compared with the dubious survival of many other tagged young, is rather strong, though limited, evidence that they enjoyed the advantage of normal upbringing.

Although data on two foxes hardly justify much in the way of conclusions, they hint that the dispersal of the young naturally takes place in easy stages. It is a temptation to speculate how a maturing young fox wanders farther and farther afield (with perhaps increasing encouragement to do so on the part of the resident parents), gradually extending its radius of familiarity

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and finally establishing itself wherever chance, choice, convenience, or necessity may determine. We have no clear evidence as to just when the young take up regular residence, but field data indicate that many stay with their parents until as late as the first week of September.

The recorded history of 236 young foxes released shortly after capture and tagging but at some distance from the home ranges of the adults, shows that 16 were trapped or shot during the following winter, and 1 during the second winter. A total of 17 returns, or 7.2 per cent of 236 possibilities, does not suggest a high rate of survival. The data in this category relate to animals released in May or early June, as a rule, and usually when about three-fourths grown. Individuals that were obviously too immature to stand any chance of looking out for themselves were kept in captivity until they attained a more suitable size.

There was great variation in the distances from the points of release at which the 17 foxes were killed. The extremes were 2, 4, 5, 90, and 96 miles, with an average and median distance of 30 miles.

Of 55 tagged foxes that escaped or were released from captivity at the age of several months, 10, or 18 per cent, were reported killed, all during the winter following. Two were found killed by traffic in the vicinity in which escape was made; another was trapped 10 miles away; and one was shot 160 miles distant. The average distance was 51 miles; the median, 20 miles.

These foxes were usually confronted by their first problems of freedom in late summer or early fall, or at about the age when at least some parent-raised young are similarly learning to hunt. One may judge from the higher rate of returns that young liberated at this season have materially greater chances for survival than the pups released in the spring; but how well their chances compare with those of parent-raised young is indeed difficult to say.

We are inclined to doubt that the failure of the partly grown foxes released in May and June to make a better showing is attributable mainly to starvation. On the basis of data on the general food habits of Iowa red foxes, it is our belief that the young, when they first start forth "on their own," subsist chiefly upon grasshoppers, crickets, beetles, Lepidoptera and Coleoptera larvae, frogs, snakes, some mice and other small or young mammals that are easily caught, carrion of fresher grades (especially from along pavements), garbage, certain vegetables and fruits—in short, essentially what one might expect hungry and unskilled young Canidae to procure. This sort of living is more or less available throughout the summer to young foxes at all diligent in their foraging, whether 2 or 4 or 5 months of age.

While guidance or example of the adults doubtless smoothes the path of the young in many ways, much of it may not actually be necessary to their existence. On the other hand, parental care during the midsummer months is likely to be an important factor in keeping the young out of trouble in

general, and especially in affording them a measure of protection against dogs.

The subsequent movements of young foxes released in spring, summer, or fall appear equally unpredictable, but animals not forced to shift for themselves until they are nearly fully grown unquestionably experience the least handicap.

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Iowa Conservation Commission, Des Moines, Iowa

A PRELIMINARY STUDY OF THE BIGHORN OF YELLOWSTONE NATIONAL PARK

By Harlow B. Mills

For many years the condition of the bighorn, *Ovis canadensis canadensis*, in Yellowstone National Park has not been favorable. Although the animals have been rigidly protected, and their natural enemies are not so abundant in the Park as formerly, their numbers, according to estimates, have remained quite continuously around the 200 mark. This static condition cannot be due to dearth of range, for Bailey (Animal Life of Yellowstone National Park, 1930) suggested that there may be range in the Park for 2000 animals without encroachment on that of other game animals.

With the object of attempting to discover the adverse factors affecting the bighorn, studies were carried on throughout the winter of 1934 and 1935 under the direction of the Wildlife Division of the National Park Service. During the 9 months that these studies were prosecuted, a considerable amount of biological data has accrued. The purpose of this paper is to present some of these data, together with some conclusions which have been reached.

History.—A perusal of the Annual Reports of the Superintendents of Yellowstone Park does not yield much information concerning the early numbers of bighorn in this region. The first record (1880) stated that sheep were abundant. In 1887 they were found in all of the mountain ranges of the Park, and the first mention of bighorn wintering on Mt. Everts is recorded, a band of 8 having been seen in that vicinity.

In 1892 several bands were seen. In 1896 the flocks were reported to have shown great increase, and the report of the next year gave an estimate of 200 in the Park, 30 of which wintered on Mt. Everts. In this year they were reported as increasing, and it is somewhat surprising to find in the Superintendent's report for the next year the statement that there were not many in the Park. However, 56 wintered on Mt. Everts during the winter of 1900–01.

It was estimated in 1903 that there were over 100 in the Park, and in 1905 the estimate was the same. Two years later the number was set at 200, in 1911 at 250, and in 1912 at 210. In 1914 it was noted that they were tame and in excellent condition. The number in 1916 was set at 200.

Game census reports from 1922 to 1933, inclusive, give a more accurate picture of the numbers in the Park, the actual figures for these 12 years being as follows: 233, 200, 217, 195, 215, 346, 170, 77, 125, 101, 79, 82. These figures no doubt are better than the earlier estimates made when observations were incidental to other duties. It is likely that the flocks within the confines of the Park aggregated more than the earlier estimates indicate.

If this be the case, we have the interesting condition of a species decreasing under protection both from man and its natural enemies. The causes for losses of bighorn in the past are partially known. Disease has at times caused a reduction in the numbers of sheep in the Park. It is at the present time incipient and potentially dangerous.

Numbers, Distribution, and Migrations.—The number of sheep known to inhabit the northern area of the Park and adjacent territories during the winter of 1934–1935 is as follows:

LOCATION	CLASS			TOTAL SEEN	ESTIMATED	TOTAL	OBSERVER OR AUTHORITY
	Rams	Ewes	Lambs				
Cottonwood	1	6		7		7	G. Walker
Tower Falls	3	5	3	11		11	H. B. Mills
Specimen Ridge	4	9	4	17		17	"
Quartz Creek	4	13	7	24		24	"
Tower Falls					5	5	"
Oxbow Crags					5	5	E. R. Arnold
Soda Butte					30	30	F. Anderson
Mt. Everts	14	24	14	106		106	H. B. Mills
Turkey Pen	1	9	5	15			"
Daly Creek					35	35	R. Grimm
Totals	27	66	33	165	75	240	

Bighorn have been recorded in the winter from Mt. Everts, lower Gardiner River, mouth of Bear Creek, Sepulcher Mountain, Oxbow Buttes, Junction Butte, Mt. Norris, Specimen Range and the Buffalo Plateau. In the summer they have been reported from Mt. Everts, Sepulcher Mountain, the Gallatin Range, Daly Creek, Mt. Washburn, Observation Peak, Prospect Peak, Crevice Region, Bunsen Peak, Garnet Hill, Yellowstone Canyon, Cutoff Mountain, Republic Pass, Abiather Mountain, The Thunderer, Mt. Norris, Eagle Pass, Two Ocean Pleateau, Big Game Ridge, Mt. Sheridan, and the Trident Plateau.

As with the elk or wapiti, the fall and spring migrations are neither absolute nor complete. The majority of bighorn, however, descend to lower levels and concentrate into larger flocks for the winter. In at least one place they apparently rise to higher levels for the winter season.

Five probable migration routes are known at the present time: 1. Bighorn which summer at the head of Daly Creek pass eastward across the divide into the Yellowstone drainage. Their winter range is uncertain, but may include the area from Sepulcher Mountain north to Yankee Jim Canyon. 2. Bighorn in the South Gallatin range pass north of the Swan Lake flats to Terrace Mountain and the Hoodoos, passing from there down Glenn Creek to the Gardiner River, and Mt. Everts. 3. The summer flock on Mt. Washburn passes behind the Tower Ranger Station, crosses the loop road near Crescent Hill, and probably by several routes reaches Mt. Everts for the winter. 4. From the upper Absarokas in the region of Cutoff Mountain, bighorn pass west and north of the Slough Creek meadows to winter on the Lamar River and Junction Butte. 5. A winter flock on Specimen Ridge near the head of Quartz Creek possibly is composed of animals that summer below on the east side of the Yellowstone Canyon. Snow depths in the canyon may force them up to the wind-swept reaches of the ridge.

Calls and Communication.—In the fall, the bleating of lambs is commonly heard, but no other vocal communication has been noted. Upon approaching a flock, one individual may raise its head some time before the remainder are aware of one's approach. In connection with this point, the following is of interest: On November 23, a flock consisting of a young ram, 6 ewes, and 3 lambs, was located near Junction Butte. Although the animals repeatedly started away, they were brought back to me several times by my mimicry of the bleat of a lamb. One ewe was especially attracted by the call and led the flock back, apparently against its inclination.

Daily Routine.—On the summer range the bighorn often are feeding at daybreak. Breakfast lasts until the middle of the morning, when the sheep lie down until noon. After noon there is a period of feeding approximately two hours in length, followed by a rest lasting until about 5 P.M., after which feeding is resumed and continued until dusk, at which time they bed down for the night.

On winter range the above procedure is varied to some extent. Under average conditions the bighorn may not rise until after 8 A.M., when feeding commences and continues until nearly noon. After two or three hours' rest, feeding is resumed, and continues until dark.

Under conditions of deep snow, bighorn near Junction Butte have been noticed to remain in their beds until after 9 A.M., feeding continuously thereafter until about 5 P.M., when they bedded down for the night. If a water supply be close at hand, a flock in the winter often will feed within a one-eighth mile radius of its bedding area.

Tracks and Sign.—It has not been possible to find characters that will always distinguish the droppings of bighorn from those of antelope and deer, with which they may be confused. Typical antelope droppings are elongate-elliptical and are not usually to be confused with those of sheep. Bighorn pellets are generally slightly smaller than those of deer, and are less elliptical. The pellets are usually distorted by colonic and rectal pressure. A typical pellet is longer than broad, concave at one end and slightly tipped at the other. The pellets are most often free on the ground, but occasionally groups of three or four adhere, and sometimes the whole mass clings together loosely. The number of pellets in four representative piles was 139, 161, 206, and 110, averaging 154 per pile.

The tracks of these three animals are more easily separated. The apices of the hoofs of bighorn are held farther apart, and generally point directly forward, rather than being close together as in deer and antelope. They are not so symmetrical in outline as those of the last two animals, often being slightly concave in outline along the outer margin. The tracks are usually convex on the face, due to the hollowed pocket in each hoof.

Bighorn trails are characteristic of known habits, usually following just above or when possible just below the rim of a crest, or winding about among the crags of their habitat. In the Park their trails are evident and unmistakable in such places as the crest of Mt. Everts and the rim of the Yellowstone Canyon.

Reproduction.—The first signs of the rut were seen on October 18, on Mt. Everts. Mating attempts were half-hearted at this time, and the rams were very fraternal. By the middle of November the rut was well under way, and by the middle of December it had reached its climax. After this time there was a gradual subsidence of the mating fever, until the last evidence of it was seen on March 4. Bailey (loc. cit.) quoted Mr. Donald Stevenson as observing that in the Wind River Mountains an old ram is found in each band of ewes during the rut, and he attempts to exclude other rams from the flock. Observations of the past winter did not substantiate this statement.

Rams mixed freely with the flocks of ewes, several of them usually pursuing one ewe. The rut at its height becomes a veritable craze. On December 12, a flock of 9 rams was seen in pursuit of a young ewe. When she was stationary in the shelter of some large rock, the rams, with heads up and nostrils distended, were as still as statues. Upon her slightest movement there was a lightning-swift convergence of 9 thunder-bolts upon her, and winded though she was, she would break for another ravine where protection could be found. It would seem a physical impossibility for a normal ewe to go through the mating season without becoming pregnant. The rut not only leaves the rams with bleeding noses and splintered horn tips, but limping rams were common in December, and on the 18th of that month a ram was found dead along the Gardiner River with a twelve-inch length

of a cedar branch penetrating its side. It apparently had fallen or had been pushed with such force that the branch penetrated the body cavity.

A ram, observed along the Gardiner River for several days, was seen to be in an emaciated condition. It was found dead on March 12. When the tissues were cleaned from the head, it was discovered that there was a skull fracture near the base of the left horn extending from the occiput across the vertex to within an inch of the left orbit. The fracture was 6 inches long and at its widest point three-eighths inch across.

Loss of Lambs.—It has been stated that there is no reason to believe that normal ewes should not become pregnant during the rut. In the fall, however, there is a conspicuous scarcity of lambs. Leopold (Game Management, 1933) gave an assumed ewe-lamb ratio of 1:1.5 with, however, a query. Sixty-six ewes were seen in the northern part of the Park with 33 lambs. This number of ewes includes those too young and too old to breed. Arbitrarily deducting 6 animals for these classes (a conservative figure) we had a ewe-lamb ratio of 60:33, or 1:0.55. This means a reduction of nearly two-thirds the theoretical lamb crop, if we take Leopold's ratio for want of a more accurate one.

This dearth of lambs needs to be evaluated before we can understand our problem. We know of no abortion disease affecting the bighorn. It is more likely that there is a gradual loss throughout the spring and summer, possibly due to disease, climatic factors, or predators.

Food.—Although bighorn are possessed of very delicate food habits, a review of the literature reveals an interesting versatility in this regard. Mr. W. B. Davis, former naturalist assistant in Yellowstone Park, listed the following plants as being consumed in early July by bighorn sheep on Mt. Washburn, together with the percentage of utilization of each:

Poa sp.	60 p. c.
Pedicularis cystopteridifolia	25 p. c.
Polygonum bistortoides	5 p. c.
Erigeron sp.	5 p. c.
Eriogonum umbellatum *Picea engelmanni* *Pinus albicaulis*	5 p. c.

Observation of bighorn on the winter range leads one to the conclusion that grass comprises about 98 per cent of the food consumed at this time of the year. For long periods of time bighorn were seen to feed on nothing but grasses of the genera *Festuca*, *Koeleria*, and *Stipa*, together with other undetermined forms. Examination of the rumen contents of a four-year-old ram and a young ewe substantiated visual evidence. In these stomachs the contents were entirely of grasses except for traces of *Pseudotsuga taxifolia* and *Juniperus scopulorum* in the rumen of the ram, which had been feeding beneath these trees along the Gardiner River. Bighorn were seen to paw

through 6 to 8 inches of snow to reach sparse, short grasses, when they were surrounded by shrubs extending high above the snow. Under unfavorable conditions, the giant rye grass, *Elymus condensatus*, was used for food, the animals following up the coarse stem to pick off the leaves.

Various shrubs and trees occasionally enter into the diet. On January 17, the bighorn descended to the steep slopes of the Gardiner River to escape a strong wind in sub-zero weather. At this time they fed about 40 per cent of the time on rabbit bush (*Chrysothamnus* sp.), sage (*Artemesia tridentata* and *A. frigida*), skunk bush (*Rhus trilobata*), and Douglas fir (*Pseudotsuga taxifolia*). They also were reported by Dr. Adolph Murie to be feeding on willow twigs along the river.

In early April, bighorn were reported by Mr. Frank Childs to be browsing foliose lichens off of rocks on Mt. Everts. These low plants must form the last resort, for when the sheep were seen eating them the range was practically depleted of food and the new grass had not started to sprout.

The winter range has been so depleted by the large bands of wapiti that the bighorn were feeding on very short grass all winter. They were observed cropping grass so closely that plants were uprooted and the roots and adhering soil were swallowed.

Losses.—In the winter of 1934–1935, 16 animals were lost from a flock of approximately 65 animals that wintered on Mt. Everts and the Turkey Pen. Causes of death were as follows: Shot by hunters north of boundary, 9; died as result of shot wound, 1; pneumonia, 1; accidental, 3; collected and autopsied, 1; cause unknown, 1.

The bighorn are exposed to poaching every winter near the mouth of Bear Creek, where they habitually feed outside the Park.

Losses from predators must be quite small on the winter range. The abundant coyote is at present the only predator of any importance to the sheep in the Park. Although coyotes were commonly seen about the bighorn, there was no actual evidence that they made attacks on the flocks. An interesting incident involving the two species was witnessed the morning of November 9, 1934. While watching a flock of rams, I saw a coyote trotting down wind toward them but hidden from their view by a rise. When it reached a point about 150 yards from the bighorn and still was invisible to them, they broke into a run toward a cliff behind them, spending the rest of the day within its protection.

Eagles have long been considered as enemies of bighorn. In this connection there is an interesting note recorded in the report of Superintendent P. W. Norris for 1880. In part, he wrote: "This bird (the eagle) hovers about to pick up the lame and wounded, and terribly annoys the bighorn sheep. In one instance it caused a lamb to fall from a towering cliff and thus secured a repast below, but from my position I was unable to observe

whether the lamb was frightened from its place on the cliff, or hurled off after being crippled by the eagle's talons, beak or wing."

Twice this winter golden eagles have been seen soaring above the bighorn on Mt. Everts, but in neither case did the animals show any alarm. One bird was perched in a tree within 100 yards of a flock on Specimen Ridge in December, without exciting the flock in the least.

Parasites and Diseases.—Two diseases, scabies and lungworm infection, have caused reduction of the bighorn population in this region. At the present time these diseases are incipient in the flocks and are potentially dangerous. The scab mite, *Psoroptes communis ovis*, was found in the ears of a dead ram. The exudate caused by the infestation had completely closed the auditory meatus on either side. Several specimens of the winter tick, *Dermacentor albipictus*, including males and unengorged and engorged females, were taken from the venter of the same ram. No further evidence of external parasites was noticed during the winter. Biting flies of the genera *Tabanus* and *Chrysops*, however, were noted attacking sheep on Mt. Washburn in the summer.

Two animals that were sufficiently well preserved for study, a five-year-old ewe and a four-year-old ram, were examined for lungworm. In both cases the lungs bore numerous abscesses, and smears indicated the presence of multitudes of lungworm larvae. The lungs of the ram were especially involved. A lung of the ewe was submitted to the Bureau of Animal Industry, Washington, D. C., by Dr. Hadleigh Marsh, of Bozeman, Montana. Two different lungworms were located by the Bureau's laboratories, *Protostrongylus stilesi*, and another species, probably *Elaphostrongylus odocoilei*. Males of the latter are necessary for determination and were not found in the material submitted.

Bighorn have been seen coughing violently both at Junction Butte and on Mt. Everts. This was especially true of the lambs but was in no way limited to them. A large ram was reported, in November by Wm. E. Kearns, as being nearly in convulsions from prolonged and violent coughing.

Nematodes were present in the abomasum of the ewe. They were collected by Dr. Hadleigh Marsh and identified by the Bureau of Animal Industry as *Ostertagia marshalli*. One specimen of *Cysticercus tenuicollis* was taken from the intestinal mesenteries of the ewe, and two were found in the ram. No active necrotic stomatitis was seen. Two rams exhibited exostosis of the lower jaw, however, which was probably due to an old case of this disease.

Conclusions and Recommendations.—Although there is an abundance of excellent summer range for a large number of bighorn in Yellowstone National Park, the winter range of this species is in a deplorable condition. This has been brought about by drought and the grazing of the large, abun-

dant, and versatile wapiti. The winter forage for bighorn on Mt. Everts and Specimen Ridge is very sparse and short, and the continued feeding on this type of range is bound to continue and to aggravate infections of internal parasites.

Reduction of the wapiti herd, which is being carried on at the present time, will relieve to some extent the pressure of the bighorn winter range. Further and very necessary benefit will be effected by the purchase of land to the north of the Park, providing an outlet for the high concentration of the wapiti along the north Park boundary. It will take not only this but several years of normal rainfall to bring the winter bighorn range back to a semblance of conditions of a decade ago.

The congregation of a large number of bighorn in a limited area, as on Mt. Everts, is not desirable. Artificial feeding has not been practiced in this region for several years, and none will be carried on in the future. The bighorn should not be encouraged in any way to congregate in large numbers in any area. Possibly when range conditions balance the game population again, they will not concentrate as they do at the present time.

The bighorn are in constant danger from poachers near the mouth of Bear Creek, where 9 were killed illegally during the winter. Another, a ram, was found dead on Mt. Everts with a shot hole passing through the skull narrowly missing the brain cavity. The area near the mouth of Bear Creek should be closed to all hunting or, better yet, added to the Park.

The destruction of predators that attack bighorn is not to be desired. Bighorn are notably susceptible to disease. The value of many animals lies in the fact that they are scavengers, destroying the bodies of animals which cause pollution of food or water, or otherwise aid in dissemination of disease. Predators that kill and devour the sick or weak individuals while they are highly infective and associating with healthy susceptible animals, are of more value than are the scavengers. Within reason, and under thorough observation, the present predators should be protected. The spread of the breeding season seems abnormally long (October 18 to March 4). Should mating be successful as early as the middle of October (the gestation period being 150 days according to Seton, Lives of Game Animals, 1929), the lambs would be born the middle of March. Likewise, if mating were successful the first of March, the lambs would be born the first of August. In either case the chances of survival of such lambs would be small.

Spring and summer loss of lambs is too great, and the cause must be ascertained for a complete understanding of the problem of the bighorn in Yellowstone National Park.

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SUMMER FOOD HABITS OF THE BADGER IN NORTHWESTERN IOWA

By Paul L. Errington

From 1932 to 1935, it has occasionally been possible to make limited observations on the badger (*Taxidea taxus*) in the lake and marsh country near Ruthven, Iowa. In one instance, the destruction of the nest of a ring-necked pheasant (*Phasianus colchicus torquatus*) was traced to this species (F. N. Hamerstrom, Jr., Iowa State Coll. Jour. Sci., vol. 10, pp. 173–203), but the difficulty of obtaining definite data relating to food habits and behavior was considerable. Prior to 1936, the identity of the probable badger feces now and then encountered was not regarded as sufficiently certain to justify the recording of their contents. The general evidence gleaned from examination of diggings and the less doubtful fecal remains was that the animals were feeding largely upon ground squirrels.

During the summer of 1936, however, I had an exceptional opportunity to do some work on the badger population of the 392-acre tract of reverting prairie known as Dewey's Pasture, a few miles north of Ruthven. Dewey's Pasture was purchased in 1934 by the Iowa Fish and Game Commission as a breeding area for waterfowl. At that time drought and over-grazing had left in the higher portions little surface vegetation other than clumps of *Symphoricarpos* and the usual pasture growth of such plants as *Verbena*, *Solidago*, and *Ambrosia*. With rainfall and relief from grazing in 1935, a lush stand of grasses, chiefly of *Poa*, covered the bare spaces. In 1936, while the drought dried up the sloughs and pot-holes in the area, and cut short the growing season of much vegetation, the ground still had a mat of cover rarely less than several inches in depth.

Thirty-seven fecal passages were collected from the vicinity of freshly or regularly used badger diggings or dens. All but 5 of these were typical badger feces and were not to be confused with those of any other carnivores frequenting the area. The 5 atypical passages as a rule were of smaller size and were composed conspicuously of insect débris; but, as 2 contained badger fur evidently licked from the body of the animal itself, the identity of these should be considered as reasonably well established.

The age of the feces could be ascertained within two weeks or less, and the results of the analyses illustrate the trend of local badger food habits from early June to late July. Dr. H. H. Knight handled the identification of the more difficult insect items, and Mr. L. J. Bennett examined questionable specimens of duck-egg shells.

First half of June, 1936: 11 fecal passages. Ten of the 11 passages contained bones and fur of the striped ground squirrel (*Citellus tridecemlineatus*)

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in substantial quantities. Remains of Franklin's ground squirrel (*C. franklinii*) were found in 1. The ground squirrel remains were principally those of adults; but numerous bones of immature individuals, including some that were very young, could be distinguished in 4 passages.

Remains of meadow mice (*Microtus*) were heavily represented in 3 passages; and were represented in lesser quantity in 3 more.

Four passages contained bird egg shells, usually in traces. The representations were 2 of blue-winged teal (*Querquedula discors*); 1, probably ring-necked pheasant; 1, grebe (doubtless pied-billed grebe, *Podilymbus podiceps*). Breast feathers of teal and pheasants and dry grass leaves mixed among the egg shell fragments were judged to be merely contents of the nests, eaten incidentally with the eggs. The grebe egg may have been near the hatching point when eaten, as associated downy material checked well with the down of newly hatched grebe chicks in the reference collection.

One passage contained egg particles of an undetermined reptile.

Traces of finely broken insect chitin (Formicidae, Chrysomelidae, Carabidae, and undetermined Coleoptera) were found in 4 passages, evidently residue from the stomachs and intestines of the ground squirrels. Insects in 2 passages had apparently been eaten directly by the badgers; one passage contained a single water beetle (*Dytiscus*) and the other a mass of adult bumble bee (*Bombus*) remains.

Second half of June, 1936: 8 fecal passages.

Four of the 8 passages contained remains of striped ground squirrel in considerable quantity; 2, traces.

Meadow mice were represented heavily in 5 passages and by a trace in 1. There was also a trace of deer mouse (*Peromyscus*, probably *P. maniculatus bairdi*) in 1 and traces of undetermined mice in 2 others.

Blue-winged teal egg particles were found in rather small quantities in 2 passages. Feathers of adult pied-billed grebe comprised about 40 per cent of one passage; and, in addition to grebe egg shells, bone traces of at least 2 week-old young were distinguished.

The latter passage also contained bone fragments of at least 3 frogs (*Rana*).

Finely broken insect chitin, probably food of the rodent prey, was found in 1 passage; in 4 others the insects apparently had been eaten directly by the badgers. Of the 4 representations, 1 was of a single Lepidoptera larva and 1 was of a cricket (Gryllidae). The 2 heavier insect representations consisted mainly of Coleoptera, with a combined identified total of 71 *Bolboceras*, 1 *Necrophorus*, 1 *Pasimachus* and 10 Carabidae further unidentified, besides 3 Lepidoptera larvae.

First half of July, 1936: 15 fecal passages. Striped ground squirrel remains were heavily represented in 11 passages and by a trace in 1. Evidences of both adults and young were often to be found together in the same passages; but the young at this time of the season had so nearly attained

the size of the adults that they could commonly be recognized only by the condition of their bones. Two representations of Franklin's ground squirrel were of immature individuals.

Meadow mouse remains were heavily represented in 3 passages and were present in greater or lesser quantity in 3. One passage contained traces of an undetermined mouse.

Traces of blue-winged teal eggs were represented in one passage; and in another was a considerable quantity of egg shells and down from the nest.

A considerable representation of turtle eggs in 1 passage appeared to be of Bell's painted turtle, *Chrysemys marginata belli*.

Traces of insect débris, probably from the alimentary tracts of the rodents, were found in 7 passages, and were largely of Formicidae, small Coleoptera, with single examples of Lepidoptera larvae and grasshopper (*Melanoplus*). One passage contained remains of a coleopterous larva, evidently eaten directly; and in two passages, insects were heavily represented by adult *Phyllophaga* in one case and by *Phyllophaga* larvae and adult bumble bees in the other.

Second half of July, 1936: 3 fecal passages. The few passages for the second half of July perhaps may contribute more clearly to the picture of summer food habits of the badger if the contents be described individually.

Remains of striped ground squirrels, adults or of adult size, together with some finely broken insect débris, comprised one entire passage.

About 40 per cent of the second passage consisted of meadow mouse bones and fur, and the rest was of Dytiscidae and Carabidae (chiefly *Harpalus*) remains in approximately equal proportions.

Aside from traces of undetermined fish bones and some badger hair, the third passage was formed exclusively of insect material, about 65 per cent consisting of the nest and adults of the hornet, *Polistes*. Among the other insects eaten were Scarabaeidae (probably *Phyllophaga*), *Pasimachus*, *Calosoma*, and Carabidae close to *Chlaenius*.

Discussion.—For June and July as a whole, remains of ground squirrels (mostly striped) comprised a calculated 53 per cent of the fecal bulk examined; mice (mostly meadow mice), 30 per cent; insects (mostly Hymenoptera and Coleoptera), 9 per cent. The balance consisted of feathers (grebe, with breast or down feathers of teal and pheasant), egg shell particles, miscellaneous avian and lower vertebrate debris, undetermined items, amorphous waste, dirt, and grass leaves and other vegetation probably swallowed incidentally. These proportions should provide a fairly accurate index as to the relative quantities of food types eaten, except for the eggs and for soft foods of which little or no residue might be detected in the feces.

Six passages were predominantly of insect remains and it is suspected that most of these were voided by young animals. The lickings of badger hair found in two insect-containing samples appeared to be somewhat less coarse

than the hair on an adult pelt examined. Since heavy pressure on ground squirrels continued up to the last fecal collections in July, it would seem very probable that the adult badgers find the food that may be procured by digging as conveniently available as any; whereas the less powerful and less skilled young may have to supplement their diet from sources presumably more accessible to them, i.e., foods from the surface of the ground rather than from under the surface.

Insects are a staple food for the young of many species of predatory birds and mammals, especially when they are first learning to shift for themselves. The adults, however, may also feed actively upon insects during periods of conspicuous availability, so we are not justified in assuming too much on this point.

The influence of availability of food on the feeding habits of old badgers, as well as of young, is suggested by the occurrence of either avian or reptilian egg shells in 11 of the 37 passages. Similarly, the occurrence of aquatic material (remains of adult grebe and of grebe eggs and young, in addition to remains of fish and of Dytiscidae) in 5 passages suggests not only foraging about the margins of the drying sloughs, but taking full advantage of the food thus being made easily available.

Nests of ground nesting birds seem to be rifled as the badgers may chance to encounter them. On an estimated total of 2.3 acres carefully worked over in the neighborhood of the badger diggings and apparent hunting grounds, 3 blue-winged teal and 2 pheasant nests were found. The 2 pheasant nests and 2 of the teal nests hatched successfully, while the third teal nest, situated 35 feet from the nearest of a set of well-used badger holes, was destroyed. An incomplete clutch of 4 teal eggs was accidentally discovered on May 12; the female flushed violently and did not return, and some weeks after desertion the eggs were eaten after the manner of badgers.

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THE SWIMMING MECHANISM OF THE PLATYPUS

By A. Brazier Howell

In many respects the monotremes are the most primitive of the Mammalia, while in others they are uniquely specialized to a high degree. In limb characters they are essentially reptilian, to such an extent that one is forced to believe that their reptilian ancestor was considerably different from that of therian mammals.

In spite of the fact that the habits of *Ornithorhynchus* are so different from those of *Echidna* and its allies, both show much similarity in the adaptational features of the anterior appendages, as is to be expected from the fact that the movements involved in digging are somewhat the same as those used in swimming. The aquatic modifications of the platypus are unique among mammals, and indeed, among vertebrates, and may be described as showing a high development of an originally inefficient approach to swimming technique. The reason for this was evidently that the platypus had no aquatic enemies of any consequence and was not forced to develop much speed in swimming. During many millions of years it has acquired aquatic adroitness, but yet its method of swimming is fundamentally inefficient.

It is clear, from the photographs and descriptions of Burrell (The Platypus, Sydney, 1927) and others, that the platypus swims by alternate thrusts of the fore feet. The integument of the manus is projected far beyond the nails, and on the forward thrust this extension is folded back against the palm, so that water resistance is reduced, while on the backward thrust the palmar extension is expanded, so that a greater "purchase" is secured for propelling the animal. During aquatic progression the broad hind feet are held immobile, laterally, and in a horizontal position, and are used, in conjunction with the flattened tail, solely for equilibration. This method is theoretically inefficient for the reason that the animal never can travel faster than the speed at which it can retract the forelimbs. In contrast to this are the methods used by penguins, sealions, seals, and whales, which employ an oblique thrust against the water, utilizing somewhat the same principle which enables an iceboat to tack at a speed faster than the wind velocity.

The shoulder girdle of the platypus is remarkable in several respects. Of chief interest are the facts that it has well developed anterior and posterior coracoids, and interclavicle, of a type that renders it practically impossible that monotremes could have been derived from mammal-like reptiles of the Triassic theriodont type, from which therian mammals are assumed to have arisen. The point to be noted in this connection is that this osseous equipment reflects particular conditions in the muscular arrangement.

The humerus of monotremes is unique. The arcuate character of the articular part of the humeral head, so different from anything familiar in

therian mammals, indicates that the stock may well have been derived from an ancestor having a similar equipment. In *Ornithorhynchus* the arcuate shape of the humeral head (fig. 1A, 1B) is very much more accentuated than in *Echidna*, and manipulation of a skeleton shows quite clearly how this is used. If the humerus and girdle be held in articulated position it is seen that the former bone must be placed at an angle to the body of about 75 degrees, and horizontal with the ground. It is possible then to depress it only a few degrees, for the projection of the ventral lip of the glenoid inhibits farther ventral movement. If the humerus be rotated on its long axis it is seen that the head slides through the glenoid and that the head rotates over and around the ventral projection of the glenoid, which latter point continues to occupy one static position in the depression upon the ventral surface of the proximal humerus. In the position in which the manus is advanced (fig. 2E) the girdle is in contact with the humerus at the extreme anterior termination of the humeral head. When it is rotated in the opposite direction, to retard the manus (fig. 2F), contact occurs in an entirely different situation, at the posterior termination of the head.

Examination of the articular surfaces indicates that pure rotation of the humerus can take place through an arc of about 135 degrees, and that further movement at the elbow is sufficient to allow the forearm to sweep through an arc of fully 180 degrees without any deflection of the humeral axis whatever. As a matter of fact, it is hardly likely that during locomotion the distal humerus maintains at all times precisely the same fore-and-aft angle with the body axis, but it is considered that the arc so described is not more than 15, or at most 20, degrees. In this connection it is significant that Burrell offers a good photograph of a platypus running on land, with one manus fully extended and the other fully retracted. Projecting this illustration in natural size shows that the stride encompassed is not greater than can be demonstrated with a skeleton while holding the distal humerus at one point.

There is an additional interesting point in regard to the shoulder joint. It is clear that rotation of the humerus is accomplished in two directions as follows: when the anterior border is depressed, muscles must not only pull this border ventrally but also pull the humeral head forward, while other muscles elevate the posterior border. While the segment is in this position it is impossible to rotate it in the opposite direction without pulling it backward. To accomplish the latter there accordingly must be deliberate relaxation of the muscles of fixation that hold the segment forward. Presumably this is a highly useful detail. It is found in no other mammal, so far as I know, and is not a development that would have taken place haphazardly.

There also is a peculiar feature in the elbow joint. The trochlea of the humerus is almost spherical and no other articular surface occurs. To conform to this the radius and ulna together furnish a single, socket-like sig-

moid cavity. The result is an elbow joint of ball-and-socket type, allowing rotation (pronation and supination) of the forearm as a whole through an angle of at least 45 degrees. No other rotation of the forearm is possible, for radius and ulna are partially fused and the wrist joint very broad. It is clear that this type of elbow joint has been evolved to facilitate a rapid alternation of pronation and supination of the forearm, and hence manus, which is employed for maintaining equilibrium when the animal is floating. Ducks may be observed indulging in similar movements of the feet, and man

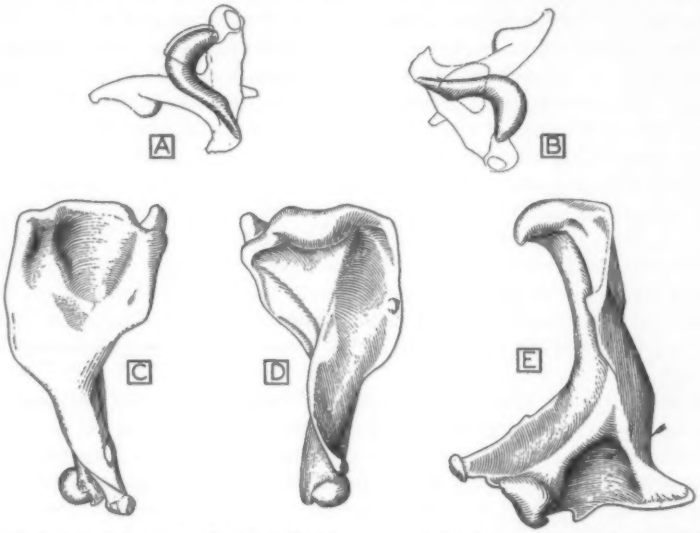

FIG. 1. A and B, proximal end of right humerus of the platypus, the articular surface shaded and position of the glenoid shown by dotted line, to show degree of rotation possible: A, with anterior border of the humerus elevated, and B, with same depressed. C, right humerus from ventral; D, from dorsal; and E, from cranial aspects. In the last the arrow pierces the entepicondylar foramen.

frequently uses his hands in this fashion when "treading water." A further point is that the trochlea is set well lateral to the humeral axis, but the advantage of this is not clear.

Such unusual conformation of the joints as is shown by the platypus might be expected to be reflected in muscular details as well, and such is the case. There are two arguments that might be advanced in this connection. (a) As the platypus holds the brachium horizontal to the ground the feet are well away from the center of gravity, and this means that during terrestrial progression a disproportionate amount of effort is required to hold the body

off the ground. When this is the case in primitive tetrapods the processes are robust and well defined, the whole humerus being very broad relative to length. The humerus of the platypus is broad but not thick, and as the animal does not spend a great deal of time travelling overland, this argument may not apply to it at all. According to a second possible argument (b), the great distance between the projected borders of the proximal humerus of the platypus may have been developed only for the purpose of furnishing increased angles of leverage for the muscles that *rotate* this segment. In this case the breadth of bone has been brought about by entirely different stimuli from those resulting in the robust humerus of early tetrapods.

The latter argument cannot apply to the distal humerus. Here the lateral epicondyle is pronounced, although not remarkably so, but the medial epicondyle is located at a surprising distance from the trochlea, to add to the angle of leverage of the flexor musculature of the forearm.

In interpreting the specialization for swimming that has taken place in the shoulder musculature of the platypus, comparison has been made with conditions in a placental mammal with fairly generalized anterior appendages, but placing the humerus in the monotreme posture. The rhesus monkey fulfills this condition in satisfactory degree, and is so employed. The monotreme muscles are listed under the names of their therian homologues, their more proper terms being given in parentheses. The heavy lines in figures 2A and 2D represent the centers of the respective muscles, or average line of pull.

Reference to the illustrations shows that the muscles in the platypus that are adapted to rotating the anterior border of the humerus in a ventral direction (inward rotation of placentals), consist of mm. subscapularis (1), teres major (2), and proscapulohumeralis (unrepresented in placentals) (3), attached to the caudal or extensor border; pectoralis minor (pectoralis) (4), panniculus carnosus (5), and supra- and infraspinati part (the more ventral portion of coracohumeralis intermedius) (6), attached to the cranial or flexor border. An additional muscle that contributes to this action, but located more distally and somewhat between the two groups, is the latissimus dorsi (7). Of these the last is predominantly a retractor.

In the macaque, muscles 1 and 5 likewise accomplish this sort of rotation, but much more weakly because of the lesser angle of leverage; 3 is unrepresented; 4 has no attachment to the humerus; the suprascapular musculature (6) has so changed in placentals as to be sharply antagonistic to this action; and with the arm in this position 2 and 7 effect almost pure dorso-retraction. Hence, contraction in the macaque of all these muscles, that in the platypus are so well adapted for inward rotation, apparently would result in no useful movement, for they would counteract each other to a large extent.

The recovery muscles, antagonistic to the above, which in the platypus accomplish elevation of the cranial border of the humerus (outward rota-

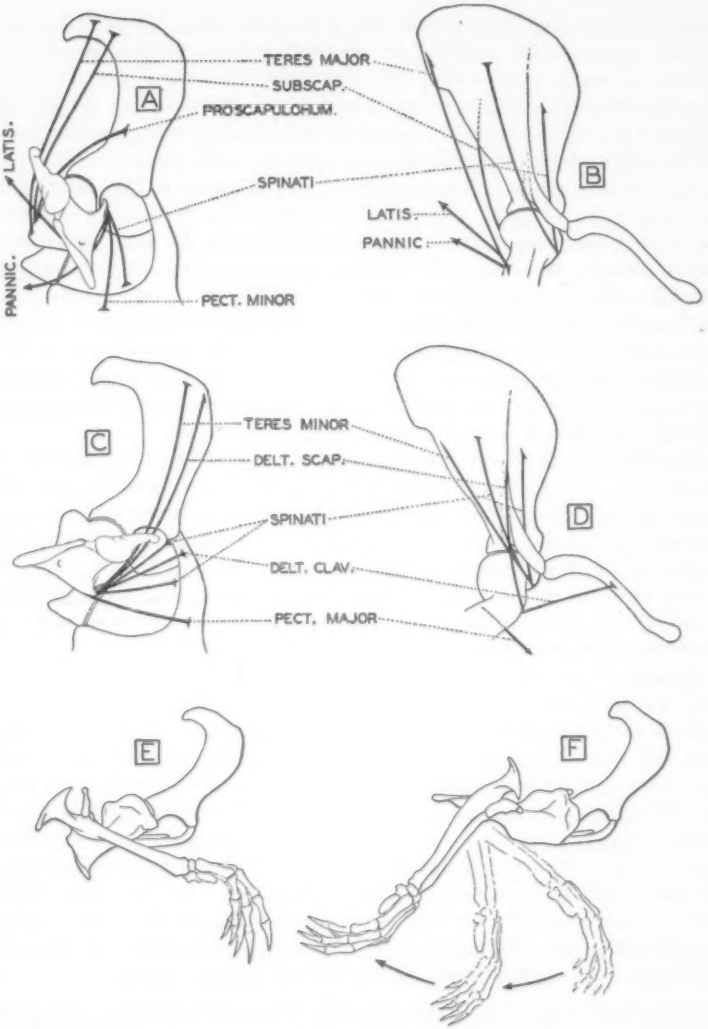

FIG. 2. A and B, scheme of right girdle and humerus of the platypus and rhesus monkey respectively, in same posture, showing positions of muscles which in the former accomplish depression (inward rotation) of the humeral anterior border. C and D, the same, but showing the muscles which effect elevation (outward rotation) of the humeral anterior border in the platypus. E, right fore limb of the platypus with manus protracted; and F, two shadow positions toward final retraction; illustrating swimming movements.

tion), comprise mm. teres minor (8), deltoideus (two divisions) (9), a part of the suprascapular musculature (coracohumeralis profundus and dorsal portion of caput intermedius) (6), and pectoralis major (coracohumeralis superficialis) (10). In the macaque, with arm in this position, the clavicular deltoid is a protractor and the pectoralis major a depressor; but the function of the other muscles is essentially the same as in the platypus, although to a much weaker degree. An interesting point in regard to the latter animal, however, is the uniformly sequential arrangement of the muscles in question. To prevent the more ventral units from protracting the arm, the latissimus can be brought into play, and doubtless others, as the panniculus, acting in fixation. The outward rotators are also vastly aided by an extension of the facial musculature from the head, which inserts strongly upon the wrist. This sweeps the manus forward, thus elevating the anterior border of the humerus. In this action the latissimus dorsi must play a very important part also, for it evidently prevents the facial muscle to the wrist from advancing the elbow to an undesirable extent.

There is one other important function of the shoulder musculature to be mentioned. As the humerus is held in a horizontal position, one would expect to find muscles well developed for fixation to prevent elevation and depression of the distal humerus. This rôle is fulfilled by a greatly specialized scapulotriceps, that originates from the scapula far dorsally, for antagonism to depressor influences, and an equally or even more powerful specialization of the deeper part of the coracobrachialis, to counteract undesirable tendencies for elevation of the elbow.

In summary, it may be said that in the platypus the bones of the forearm exhibit a very remarkable adaptation for efficient rotation of the humerus, both in the joints and in the projection of processes. These are correlated with the musculature, the latter, however, showing a less extreme modification than the osseous details. The muscles themselves are finely adapted, by relatively minor alterations, to coöperate in accomplishing rotation, but on the whole they are not very different from the pattern characteristic of reptiles, their efficiency being attributable largely to the development of processes furnishing effective angles of leverage. In this connection it must be remembered that specialized functioning of the limbs does not depend solely upon osteological and myological conformation, but also upon coördinated control developed by the central nervous system.

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THE COMMON NAMES OF MAMMALS

By Lee R. Dice

The English names that have been applied by naturalists to North American mammals are not all satisfactory, and many of them remain largely book names. Nevertheless, the constantly growing interest in all kinds of wild life makes it increasingly desirable that well chosen names be available for all our species. There is good evidence that, if no popular name be already available, a suitable book name will in time come into use as a common name.

Many of the book names that have been proposed by our naturalists demonstrate a singular lack of imagination. They are often clumsy or otherwise inappropriate for common use. For example, the book name little brown bat, which has been applied to several species of the genus *Myotis*, is an unsatisfactory one. All the species of *Myotis* are little and brown, although some are smaller and some are deeper brown in color than others. It is no wonder that this and many others of our book names have failed of general acceptance.

Many of the smaller species of mammals do not have popular names other than those designating group, such as rat or mouse. For some species local names can be found which are adapted to wider usage, but for many of the small mammals it will be necessary to invent book names.

The larger mammals of North America suffer not from the lack of common names, but from too many popular names, which often have been wrongly applied. No matter how vigorously naturalists may protest, the popular name of the American species of *Bison* will probably continue to be buffalo, although this animal is not at all similar to the buffalo of the Old World. The moose will continue to be the moose, and properly so, even though it is the North American representative of the elk of Europe. Also the large deer (*Cervus canadensis*) of North America, which is closely related to the stag or red deer of Europe, will likely continue to be popularly known as the American elk. Nevertheless, some erroneous names can perhaps be corrected or better names applied if we naturalists can agree on suitable English appellations.

Each common name is, in my opinion, best limited to a single species, or perhaps to the closely related species of one species group. It may be difficult to find distinctive and short names for each species of the larger genera, however. Furthermore, some related species are so much alike externally that even experienced mammalogists have difficulty in distinguishing them in the field. For such groups it may be desirable to use a group name for a number of species or even for several genera. For example, it seems most suitable at present to apply the common name pocket-mouse to all the species of the genus *Perognathus*. Each species of pocket-mouse must then receive

a descriptive adjective, as rock pocket-mouse for *Perognathus intermedius*. As we come to know more about these species, however, it will probably prove desirable eventually to give each a short English name. The group name might then still be retained for all the species of the genus.

The several races of one species have rather similar general habits and characters, and persons other than taxonomists will refer most frequently to the species as a whole rather than to a particular subspecies. To designate a particular race of a polymorphic species an adjective can be added to the common name of the species. For example, prairie deer-mouse designates the subspecies *bairdii* of the species *Peromyscus maniculatus*.

In constructing book names, care must be used to avoid lengthy ones. The common name kangaroo-rat has been applied to all the members of the genus *Dipodomys*, and the species *spectabilis* has been given the book name, banner-tailed kangaroo-rat. This name is clumsy, but it becomes much worse when another word is added to designate a particular subspecies. Thus, *Dipodomys spectabilis perblandus* might be called the pale banner-tailed kangaroo-rat. It could also be called simply the pale kangaroo-rat, but that would fail to show its relationship to the other races of its species and would greatly multiply the number of kinds of kangaroo-rats. Why not call the species the banner-tail, or give it some other similar short name? A name made up of five, of four, or even of three separate words is not likely to be much used in ordinary conversation.

A fully satisfactory common name should be short, distinctive, and appropriate to the animal it designates. Names that are descriptive as well as distinctive are desirable; but it is too much to expect that every species can be given a descriptive name of universal application. The terms woodchuck and woodrat are good descriptive names, although both of these animals sometimes occur in situations where there are no woods. Book names formed by a translation of the scientific name are frequently inappropriate and in general are to be avoided.

If two words be used in forming the common name of a species, it is best, in my opinion, to combine them with a hyphen. Deer-mouse is preferable to deer mouse, because the name refers to a particular kind of mouse and has no reference to the deer as a species. It is even better, after a common name has become well established, to omit the hyphen. Woodrat and cottontail are better names than wood rat and cotton tail.

The best common name is monosyllabic, as was pointed out by Seton (English names of mammals. Jour. Mamm., vol 1, pp. 104–105, 1920) a number of years ago. It would be an impossible task, however, to provide suitable monosyllabic names for all the species of North American mammals. Furthermore, if such names were available, only a few persons at most could learn them all. We shall therefore have to allow the use of many compound names.

Some words are greatly over-used in the construction of common names. To avoid the too frequent repetition of the words rat and mouse in combina-

tions used for the names of rodents, other terms should be employed wherever possible. The word vole, which is commonly used in England, may be combined with other words to form names for the several species of *Microtus* and of related genera. For examples, *Microtus pennsylvanicus* may be known as the meadow-vole, *Microtus chrotorrhinus* as the rock-vole, and *Phenacomys intermedius* as the heather-vole. Other short names that may have been applied to the various kinds of small rodents can probably be found if sought, and some of these names likely will be useful as common names.

As an example of what I consider fairly satisfactory book names, I have attempted to provide a distinctive English name for each species of the genus *Peromyscus* occurring north of Mexico, as follows: deer-mouse, *Peromyscus maniculatus;* beach-mouse, *Peromyscus polionotus;* Sitka-mouse, *Peromyscus sitkensis;* wood-mouse, *Peromyscus leucopus;* cotton-mouse, *Peromyscus gossypinus;* brush-mouse, *Peromyscus boylii;* encinal-mouse, *Peromyscus pectoralis;* pinyon-mouse, *Peromyscus truei;* juniper-mouse, *Peromyscus nasutus;* golden-mouse, *Peromyscus nuttallii;* gopher-mouse, *Peromyscus floridanus;* canyon-mouse, *Peromyscus crinitus;* chaparral-mouse, *Peromyscus californicus;* cactus-mouse, *Peromyscus eremicus.*

Most of these names have been previously used, at least as book names, but some of them are here proposed for the first time. The term Sitka-mouse refers to the district in which the species *sitkensis* occurs. The name encinal-mouse has reference to the occurrence of the species *pectoralis* in the oak forests or encinal of Texas. Major E. A. Goldman informs me that it also occurs in encinal in Mexico, although it ranges widely in habitat. Juniper-mouse is applied to *nasutus* on account of its common occurrence in forests of juniper and pinyon pine. Some of these names are too long, and some are not fully satisfactory, but others are, in my opinion, an improvement on the current book names.

The term white-footed mouse, a translation of the specific name *leucopus*, has been used in the past for all or nearly all the kinds of *Peromyscus*, and it would be difficult to restrict it to any one species. This name can be retained, if desired, as a group name for all the species of the genus, all of which have white or whitish feet.

Any rigid system of common names would be most objectionable, and it may sometimes be desirable to allow a choice of two or more names. Especially should there be no thought of priority in the selection of book names. The shortest and most suitable name for any form may be expected ultimately to come into general use, unless some other name is already well established. The most that can be hoped for is to secure some improvement in the quality of our book names, and perhaps ultimately for the American Society of Mammalogists to prepare a list of generally-agreed-upon English names for all of the mammals of North America.

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NOTES ON BATS FROM THE BAHAMAS

By Glover M. Allen and Colin Campbell Sanborn

During the past two years, Field Museum of Natural History has received collections of bats in alcohol from New Providence and Long islands in the Bahamas. These were the gifts of Dr. L. A. Hodsdon of Miami, Florida, who collected on these islands in July and August, 1935, and of Dr. Jay F. W. Pearson, of the University of Miami, Coral Gables, Florida, who collected on Long Island from August 7 to 19, 1935. William J. Clench, of Harvard University, collected on Cat and Long islands in 1935 and 1936 for the Museum of Comparative Zoology. He was assisted during both seasons by H. D. Russell and John H. Huntington.

A combined account of the two collections is given here. The junior author wishes to thank G. G. Goodwin of the American Museum of Natural History for the loan of a series of *Nyctiellus lepidus* from Cuba.

Macrotus waterhousii compressus Rehn.

Macrotus waterhousii compressus Rehn. Proc. Acad. Nat. Sci., Philadelphia, p. 435, 1904. Eleuthera Island, Bahamas.

Specimens examined.—14♂♂, 22♀♀, McKinnon's Cave, Long Island (F. M. N. H.); 7♂♂, 3♀♀, Hamilton, Long Island (M. C. Z.); 3♀♀, Orange Creek, Cat Island (M. C. Z.).

When Dr. Rehn described this form, he had 9 specimens, but one of which was from Long Island. Six skulls from the largest and smallest specimens of each sex were cleaned and these agree with the description of the form and with one skull from New Providence Island.

Nyctiellus lepidus Gervais.

Vespertilio lepidus Gervais, in La Sagra's Hist. Fisica, Politica, y Natural de la Isla de Cuba, vol. 3, pt. 2, (Mamm.), p. 32, 1838, atlas (French title), pl. 1, 4 figs.

Natalus lepidus Gundlach, Cont. Mamm. Cubana, p. 30, 1877 (meas.); Dobson, Cat. Chiroptera, p. 344, 1878.

Nyctiellus lepidus Gervais, Expéd. du Comte de Castelnau, Zool., Mamm., p. 84, 1855; Miller, Proc. U. S. Nat. Mus., vol. 27, p. 340, 1904 (descr., meas.); Allen, G. M., Bull. Mus. Comp. Zool., vol. 54, p. 242, 1911.

Vespertilio barbatus Gundlach, Archiv f. Naturg., vol. 6, pt. 1, p. 356, 1840.

Nycticellus Gray, Ann. Mag. Nat. Hist., (3), vol. 17, p. 91, 1866.

Type locality.—Cuba.

Distribution.—Cuba, Isle of Pines, and Long and Cat islands, Bahamas.

Color from dried alcoholic specimens.—In Cuban specimens the tips of the hairs are very dark brown and the bases whitish. The bases show through everywhere, giving a bicolored appearance. In specimens from Long Island the hairs are brown and the bases yellowish. This yellow tinge also appears in two other West Indian bats, *Artibeus jamaicensis* and *Brachyphylla minor*.

Measurements.—Twenty from Cuba: forearm, 29.1 (27.6–30.4); 112 from Long Island: forearm 28.8 (27.3–30.0).

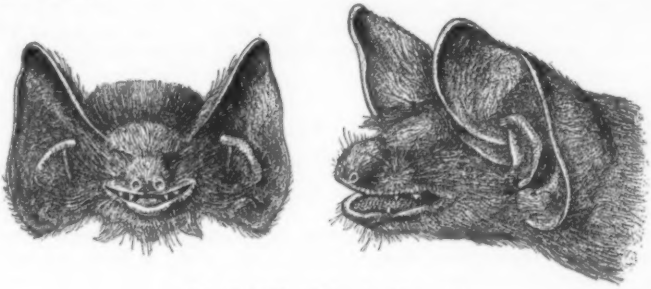
Ten skulls from Long Island, with one from Cuba in parentheses: Greatest length 13–13.5 (13.3); condylo-basal length 6.8–7.4 (7.1); interorbital width 2.5–2.8 (2.7); greatest width of rostrum 4.5–4.9 (4.7); zygomatic width 6.2–6.5 (6.4); mastoid width 6–6.3

(6.3); width of brain case 5.1–5.4 (5.2); upper tooth row 5.1–5.4 (5.4); width across canines 3.1–3.4 (3.4); width across m^2–m^2, 4.6–5 (4.8).

Specimens examined.—110 ♂♂, 2 ♀♀, Miller's Cave, Long Island (F. M. N. H.); 4 ♂♂, 2 ♀♀, Mortimer's, Long Island (M. C. Z.); 4 ♂♂, 22 ♀♀, Sheep Hill Cave, Cat Island (M. C. Z.); 13 ♂♂, 6 ♀♀, alc., Almendarez, Havana, Cuba, 1916 (A. M. N. H.); 1 ♀, near Havana, Cuba, 1917 (F. M. N. H.); 1 ♀, Isle of Pines (M. C. Z.).

This is the first time that this genus has been recorded from the Bahamas, and as other Bahama bats are all at least subspecifically distinct from the Cuban forms, it was thought that this might be the case also in *Nyctiellus*. The only separable character, however, is the color and perhaps a slightly larger ear in the Long Island specimens. The Cuban specimens have been in alcohol for 20 years and so are hardly comparable with the fresh material from Long Island in so far as the above characters are concerned.

The wings are attached on the under side of the tibia to the base of the calcar as in *Natalus* and *Phodotes*. In many specimens the calcar is bound to the lower third of the tibia and the wing appears opposite it, which seems to prove the connection between the wing and calcar.



Head of *Nyctiellus lepidus*, ×3

In the males, there is a glandular swelling about the center of the forehead and just in front of the ears. The figure showing this was made by John J. Janecek.

The preponderance of one or the other sex in the lots is interesting as indicative of only partial segregation in July.

Eptesicus fuscus cubensis Gray.

Specimens examined.—5 ♂♂, 13 ♀♀, McKinnon's Cave, Long Island (F. M. N. H.); 5 ♀♀, Mortimer's, Long Island (M. C. Z.); 1 ♂, Clarencetown, Long Island (M. C. Z.).

When these specimens were compared with *Eptesicus bahamensis* from New Providence Island, collected by Dr. L. A. Hodsdon, they were found to be the Cuban form and represent another record of a Cuban bat in the Bahamas. The measurements of this series are followed by those of three *E. bahamensis* from New Providence.

Measurements.—Forearm 44.7–49 (42.5–45.3). Five skulls: greatest length 17.5–19.4 (16.9–17.3); condylo-basal length 16.3–17.7 (15.5–16.5); palatal length 8.6–9.6 (8.3–8.4); interorbital width 3.4–3.8 (3.7–3.8); zygomatic width 11.–11.9 (11.–11.2); mastoid width 8.3–8.9 (8–8.4); width of brain case 7.5–7.7 (7.5–7.5); upper tooth row 6.4–6.9 (6.3–6.3); width across canines 5.–5.3 (5–5.2); width across m^2–m^2, 6.7–7.3 (7.1–7.1); lower tooth row 7–7.3 (6.7–6.9); length of mandible 12.7–14.2 (12.3–12.4).

Here may be recorded 11 females of this bat, taken in an old church at Cockburntown, Watling's Island (San Salvador), in February, 1934, by Dr. Thomas Barbour. This is apparently the second species of bat to have been taken on this island, the other being

the type series of *Chilonatalus tumidifrons* Miller. The forearm measurement of these 11 females ranged from 44.2–46.6, with the average 45.6 mm., which is larger than in *bahamensis* but a trifle smaller than the average of *cubensis*.

Erophylla planifrons (Miller).

Phyllonycteris planifrons Miller, Proc. Biol. Soc. Washington, vol. 13, p. 34, 1899. Near Nassau, New Providence Island.

Specimens brought back by Mr. Clench's party have been compared with topotypes from New Providence and appear to be quite the same. Colonies were found in James Cystern Cave, Sheep Hill Cave, and at Man-o'-war Rock, all on Cat Island. In the last cave was a large company consisting of adults and young ones, the latter from one-third to a little more than one-half grown. The adult taken with this lot was a female, while the young, swept up at random, included 27 males and 25 females. The date was July 9.

Specimens examined.—30 ♂♂, 36 ♀♀, Cat Island (M. C. Z.).; 7♂♂, 7♀♀, Abraham's Hill, Mariguana Island (M. C. Z.).

Measurements.—Forearm 50.3–54.5. Skull (3♂♂, 3 ♀♀): greatest length 24.5–25.5; condylo-basal length 21–22.5; palatal length (from front face of incisors) 11–11.6; interorbital width 4.1–4.6; zygomatic width 11.4–12.4; mastoid width 10.5–10.7; width of braincase 9–9.6; upper tooth row 9.4–10; width across canines 3.4–3.9; width across m^3–m^3, 7.2–7.8.

Lasiurus cf. **minor** Miller.

Lasiurus minor Miller, Jour. Mamm., vol. 6, p. 510, 1931. Near the Jacmel road, a few km. north of Trouin, Haiti.

A single specimen of *Lasiurus* was secured in July, 1935, by Mr. Clench's party on Orange Creek, Cat Island. While of adult size, it still shows a certain immaturity in the distinctness of the epiphyses of the digits. In alcohol the upper surface is rich dark chestnut without white tipping to the hairs. The forearm measures 39.7 mm., the greatest length of skull from occiput to tip of incisor, 12.6. It thus more nearly resembles *L. minor* of Haiti than it does the larger Cuban form; but this may be in part due to immaturity. Both this specimen and a female from New Providence differ from *L. seminolus* of Florida in the smaller and narrower brain case. The female shows the usual frosting of white tips to the longer hairs.

Tadarida bahamensis Rehn.

Specimens examined.—9 ♂♂, 6 ♀♀, Tatnall's, Cartwright's, Carlton Hill, Hamilton's and McKinnon's caves, Long Island (F. M. N. H.); 20 ♂♂, 28 ♀♀, near Clarencetown, Long Island (M. C. Z.).

Measurements.—Forearms 40–42.9.

Two lots of this species secured by Mr. Clench's party near Clarencetown, Long Island, came from caves a short distance apart, and showed an interesting sexual segregation. In one, 28 specimens were collected, of which only 5 were males, and each of all but two of the 23 females contained a single fetus near term. The date was July 18, over a month later than the date, June 8, on which a series from Las Cruces, New Mexico, representing *Tadarida mexicana*, was found to be carrying large embryos. In the second cave were collected 15 adult males and 5 non-pregnant females.

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Field Museum of Natural History, Chicago, Illinois.

THE NEWFOUNDLAND WOLF

By Glover M. Allen and Thomas Barbour

Many years ago, when Louis Agassiz was actively acquiring specimens of all kinds for the Museum of Comparative Zoology, he numbered among his correspondents a Newfoundland hunter and trapper, J. M. Nelson, who sent him, among other mammals, two skeletons and two skulls of the wolf from that island. These are entered in the catalogue, in the hand of J. A. Allen, as having been received in June, 1865, and doubtless were collected shortly prior to that time. No additional particulars are given. The recent review of "The Races of *Canis lupus*" by R. I. Pocock (Proc. Zool. Soc. London, pp. 647–686, 1935), has prompted us to examine this small series carefully with a view to the more precise determination of its racial status, especially since the Museum has lately received from Rev. Elwood Worcester a skin of this wolf shot by himself some 40 years ago north of Grand Lake, Newfoundland. This skin, although lacking feet and tail, and in spite of having done duty as a rug, is still in fairly good condition after naphtha cleansing. It may be added that none of this material was known to Outram Bangs when, in 1913, he published his brief paper on "The Land Mammals of Newfoundland" (Bull. Mus. Comp. Zool., vol. 54, pp. 509–516); nor, so far as we can ascertain, is the Newfoundland wolf represented by specimens in any other museum.

In 1912, Gerrit S. Miller, Jr. (Smithsonian Misc. Coll., vol. 59, no. 15, pp. 1–5), published a brief review of the names applied to North American wolves in an attempt to allocate them to recognizable species or races. He concluded that in North America, west of the Mississippi River and Hudson Bay, and north of the Platte and Columbia rivers, the wolves show three well-defined types: "(a) The timber-wolf type, distinguished by extremely large size (condylobasal length of skull in largest males about 265 mm.); (b) the plains-wolf type, moderate in size (condylobasal length of skull in largest males about 240 mm.), rostrum broad, palate wide in proportion to its length; and (c) the tundra-wolf type of the Arctic coast region, in size as in the plains-wolf, but rostrum slender and palate narrow in proportion to its length." In general the series of wolf skulls in the Museum of Comparative Zoology sustains Miller's conclusions, although it is true that certain of these average differences, while they may appeal to the eye when series are compared, are nevertheless disappointingly small when expressed as linear dimensions only. Of valid names, whether used in a specific or a subspecific sense, *lycaon* was accepted by Miller as the oldest name available for the timber wolf of the northeastern United States and eastern Canada; *nubilus* was the first name given to the plains wolf; while for the white tundra wolf of the Arctic coast, the new name *tundrarum* was proposed to replace *albus* of Sabine, preoccupied for a Siberian wolf, by *Canis lupus*

albus Kerr. Goldman (Jour. Mamm., vol. 18, p. 38, 1937) has since named the wolf of northern Labrador *Canis lupus labradorius*.

Incidentally, attention may be called to additional names that apparently have been overlooked. Thus, Sir John Richardson, in the volume on mammals in the Zoology of Captain Beechey's Voyage of the 'Blossom,' 1839, proposed "*Canis lupus*, var. *fusca*" for the brown wolf of "California and the banks of the Columbia" River, a name for this animal that antedates *Canis gigas* of Townsend (1850) by 11 years. It is validated by the reference to the "Fauna Boreali-Americana," where further particulars were given. A second name, hitherto overlooked, is *Canis lupus canadensis* proposed by Blainville for a skull which he described and figured (Ostéographie, Carnassiers, 13th memoir, "Des Canis," p. 45; atlas, pl. 7, upper right-hand figure, 1843). He gave no further locality than "Canada." The specimen was probably in the Paris Museum and may for the present be considered to be the same as *Canis lupus lycaon*, the eastern timber wolf, if that name be accepted.

In attempting to identify the Newfoundland wolf, we have assembled for comparison 30 or more skulls from North America in the collection of the Museum of Comparative Zoology, representing a wide range of localities from the Yukon to Hudson Bay and south to Florida and Arkansas. In the large size and rather slender proportions of the skull, and in the all-white pelage, the Newfoundland animal resembles the arctic race to which Miller has given the name *tundrarum*, and to which we refer a single skull of a white wolf from Hudson Bay. In certain details, notably in the short upper carnassials with their large antero-internal pillar and in the relatively short ascending branch of the premaxillary, the Newfoundland wolf seems to be well contrasted with other North American forms and doubtless represents a southern relict of the Arctic white wolf. Here it must have been cut off from the mainland for a long period, and, finding its natural food abundant in the form of the island race of caribou, it remained and developed the local peculiarities mentioned. In allusion to the now extinct aborigines of Newfoundland, the Beothuks, we suggest for this wolf the following name:

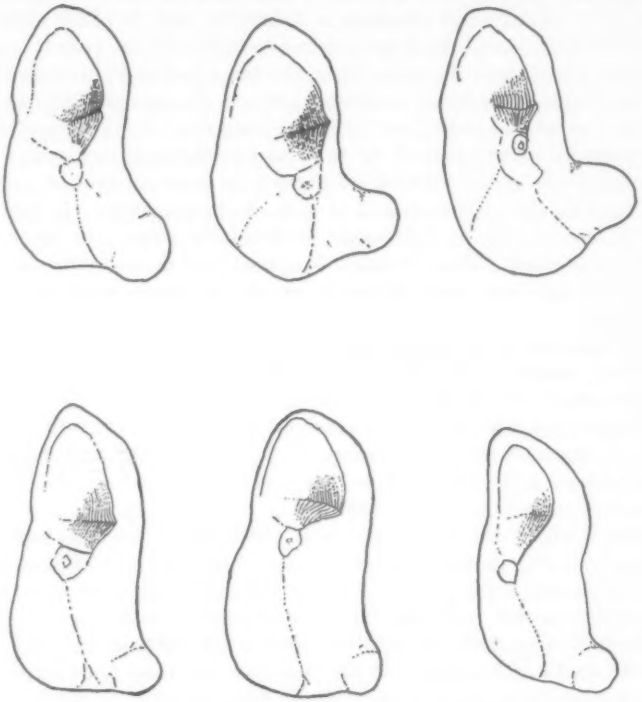
Canis lupus beothucus, subsp. nov.

Type.—Skull no. 351, Museum of Comparative Zoology, from Newfoundland; collected about 1865 by J. M. Nelson. Sex probably adult male.

Characters.—The nearly complete skin (M.C.Z. no. 28726) collected by Dr. Elwood Worcester is entirely pure white with a slight tinge of ivory yellow on the head and limbs. The under fur is dense and woolly, about 45 mm. deep on the shoulders, while the overlying guard hairs in the same region are about 160 mm. long. The short ears are densely hairy. According to Dr. Worcester, black individuals may occur.

A close comparison of the four skulls with one another and with the series

available, shows that the Newfoundland wolf attained a large size, but the proportions remained relatively slender as in the other arctic wolves. A rather striking character is seen in the very long nasals in contrast to the relatively short ascending branches of the premaxillaries. The distance



Camera-lucida outlines of the upper carnassial in crown view: upper row, left to right, Newfoundland wolf, nos. 349, 351, and 348, respectively, to show the abrupt outward curvature of the inner (right-hand) wall outward, commencing at about the level of the main central cusp. Lower row, left to right, the same tooth in a plains wolf, no. 66, from northwestern Kansas; no. 9070, in a white wolf from Hudson Bay; and no. 7410, in a wolf from Hopedale, east coast of Labrador, showing the usual condition, with smaller antero-internal lobe and slight curvature of the inner wall of the tooth, beginning farther anteriorly. All specimens in the Museum of Comparative Zoology. About twice natural size.

from the most proximal point of the latter to the tip of the adjacent nasal varies from 36 to 45 (average 41) per cent of the greatest length of the nasal, whereas in wolves from other parts of the continent it is usually about 50 per cent, with some variation.

The most striking dental characters of this island wolf are shown by the upper carnassial (pm^4) which is shortened in comparison with that of the mainland wolves examined from Labrador, Quebec, Hudson Bay, Kansas, and Alaska. A short diastema separates it from the third premolar so that the alveoli of the two teeth are some 5 mm. apart instead of being adjacent, although a similar small diastema is frequently seen in other wolves. In all four Newfoundland skulls the antero-internal accessory cusp is unusually large and prominent. In crown view, the inner wall of the carnassial in all mainland wolves examined continues forward in approximately the same straight line, well beyond the level of the main cusp, before it bends slightly and gradually inward toward the front to join the accessory cusp. In the Newfoundland skulls, this wall commences to turn outward at about the same level as the main cusp and at a much sharper angle. In two of the four, it forms nearly a right angle, while in the other two the angle is slightly less sharp. This condition is approached in our series by only a single skull, one from near Hopedale, on the northeast coast of Labrador (see fig. 1).

This difference is so uniform and so striking in the Newfoundland series, and so in contrast with the condition shown by the continental wolves, that it seems to be not a mere individual variation.

Measurements.—No external measurements are available. In the single skin, the ears measure about 80 mm. in length and hardly exceed the surrounding long guard hairs. This skin measures in head and body length, in its present condition, about 1490 mm.

The four skulls, the measurements of which follow, are fully adult, with the basal suture long closed, a high sagittal ridge, and an overhanging occiput. Number 348, the largest, is a very old male with much worn incisors and canines; in the upper jaw the three anterior premolars are lost on the left side and their alveoli all but filled, while on the right side only the stumps of premolars 2 and 3 remain. In the lower jaw, the three anterior premolars have similarly been lost and their alveoli filled in, while of the fourth premolars only a worn stump remains. Numbers 349 and 351 are fine, adult skulls, probably of males, while no. 350, from its slightly smaller size, is doubtless an adult female.

Cranial measurements of Newfoundland wolves

Number	351	348	349	350
Greatest length	265	276	255	245
Basal length	238	250	230	227
Palatal length	125	135	123	120
Zygomatic width	140	143	142	130
Mastoid width	79.2	80.4	79.8	71.8
Width outside pm^4	82	80.3	80.2	75
Upper cheek teeth, c–m^1	107	110	103	103
Lower cheek teeth, c–m_1	118	125	117	126

Length of upper pm^4	24.2	25.5	25.5	23
Length of alveoli, pm^4	21.8	23.3	23	20.6
Length of lower m_1	28	28.7	28.2	27.9
Length of alveoli, m_1	26.2	27.5	26	26.4
Outer length of nasals	97.5	103	93	88
Tip of nasal to point of premaxillary	39	47	40	32
Ratio of last distance to length of nasal	40%	45%	43%	36%

There is little recorded concerning the Newfoundland wolf. Sir Richard Bonnycastle, in his two-volume work on "Newfoundland in 1842" (London), mentioned it briefly and said that it "grows very large, is frequently traced near the capital [*i.e.*, St. John's] and does much injury to young cattle; a price is put by the legislature on its head." No doubt continued persecution gradually reduced its numbers, but it remained to follow the caribou in the bogs of the interior until nearly the present time. An anonymous writer in Forest and Stream in 1875 (vol. 4, p. 390, July 29), telling of "Some wild animals of Newfoundland," spoke of the wolf as then tolerably common throughout the island, often prowling near the houses of settlers or passing them in chase. Few winters went by without some being trapped along the shores. In winter when the caribou were feeding in the bogs, the wolves coöperated in hunting them. While some lay in wait among the border of coniferous trees, others went around to windward, when the caribou, scenting them, turned and ran directly toward the ambush. Although these wolves rarely attacked man, one instance was related of a Micmac Indian, who, in April, 1866, while standing by the side of a small lake formed by the River Exploits, saw an old wolf coming toward him on the ice, presently followed by five or six more. The Indian ran for his "tilt" and his gun, but the wolves gained on him so fast that he was forced to seek safety by climbing beyond their reach in a tree, or otherwise he felt certain that they would have killed him. After remaining for nearly an hour, they departed.

Dr. Elwood Worcester, in a letter of October 22, 1932, wrote to Barbour, in transmitting the skin above mentioned: "I must have had it for at least thirty-six years [making the date of capture about 1896]. It was very white when I killed it in the north of Grand Lake in Newfoundland. . . . Some of these wolves used to turn nearly white in the fall and early winter and some were so dark as to look almost black. I went to Newfoundland for about twelve years and traveled over a large part of the island. At that time, these wolves, though not numerous, were still fairly well represented. In the course of my travels I saw three plainly. The one I shot happened to come over the side of a hill where I was sitting with my rifle waiting for a caribou. The other two I saw very well running along the sandy shore of a lake above River of Ponds. They were chasing a caribou, and I shot the caribou from the canoe. I was always very sorry that I did not try instead to shoot one of these wolves. One looked even larger than the white one. It was dark and nearly black in color. I have seen a number of wolves in

the West and in Ontario, and it seemed to me that the old breed of Newfoundland wolves was the biggest of all." Writing about 1906, Millais in his "Newfoundland and its untrodden ways" (London, xvi, 340 pp., 1907) said that "wolves are very rare," and Dugmore, in the course of his photographic work with the Newfoundland caribou a few years later, apparently saw none and reiterated that they were "now practically extinct" (The Romance of the Newfoundland Caribou, 1913). In his paper on Newfoundland mammals published in 1913, the late Outram Bangs wrote that when Ernest Doane was collecting mammals in Newfoundland for him about 1894, a wolf was killed but he was unable to procure it. He added that "another was shot about two years ago [i.e., about 1911] which Dr. Phillips hoped he had secured, but in some unaccountable way it was lost to us. All who have seen the animal in life report it as being a pale colored wolf." Concerning the specimen mentioned, Dr. J. C. Phillips wrote us, January 1937, that he did not see it himself, and the possibility that it was a feral dog is not altogether excluded. It was said to have been shot that year. At the present time the Newfoundland wolf is probably quite gone.

It was, perhaps, somewhat unexpected that the series we have examined from this island should prove so distinct in the shortness of the premaxillaries, and in the characters given for the upper carnassial. These peculiarities must have originated, and been perpetuated, in stock isolated on Newfoundland for a very long period. It is true that the shortest distance between the mainland of the Labrador peninsula and Newfoundland is at the narrowest point about 10 miles, a distance which a wolf conceivably might cross on ice. But the Straits of Belle Isle are seldom frozen over, and it is unlikely that wolves would cross, to reach a land area invisible to them, separated by miles of inhospitable ice and open water, when caribou were to be had nearer at hand. As Bangs pointed out, when calling attention to the number of endemic forms to be found among Newfoundland mammals, most of them "have been there for an enormously long space of time." The remarkable absence of some 16 genera and subgenera of mammals that occur only a short distance away across the Straits, is, as he points out, difficult of satisfactory explanation at present.

Museum of Comparative Zoology, Cambridge, Massachusetts.

A NEW PITYMYS FROM THE PLEISTOCENE OF KANSAS

By Claude W. Hibbard

While removing gravel from the Ward Thornson farm northwest of Everest, Kansas, a road construction company encountered numerous bones of a *Mastodon* skeleton. By the time the museum was notified, all of the bones had been destroyed excepting those of a limb and a complete tusk of *Mastodon americanus*, the latter measuring 7 feet 11 inches in length. The *Mastodon* material was in a bog about 3 feet in depth which covered the gravel deposit. The bones had been discovered while removing the peatlike overburden of the gravel. In cleaning the *Mastodon* tusk a small lower jaw of a vole was discovered adhering to the tusk.

We are greatly indebted to Dr. W. H. Schoewe of the Department of Geology and Kansas Geological Survey who visited the locality and identified it as probably of the Yarmouth age.

Fig. 1. *Pitymys mcnowni*, type, no. 3851 K. U. M. V. P.; diagram of enamel pattern of right lower m_1 and m_2. ×10.

Pitymys mcnowni sp. nov.

Holotype.—No. 3851, Kansas University Museum of Vertebrate Paleontology; right lower jaw, bearing m_1 and m_2. Collected in the fall of 1932.

Horizon and Type Locality.—Pleistocene, probably Yarmouth, Brown county, Kansas northwest of Everest, Kansas, on the Ward M. Thornson farm.

Diagnosis.—Largest of the known species of the genus *Pitymys*. Salient angles broader and apices more rounded than in other species.

Description of Type.—Teeth rootless; cement present in reentrant folds; incisor passes from lingual side of jaw to labial side between m_2 and m_3; mental foramen normal; pit broad and deep between m_2 and coronoid process; large foramen opposite first outer triangle of m_2. M_1 consists of posterior loop, 5 alternating triangles and an anterior loop. The first 3 alternating triangles are tightly closed, the fourth and fifth alternating triangles are open and confluent. The apex of the first outer salient angle is more acute than that of the other salient angles. The second outer salient angle is broader than the rest. M_2 consists of a posterior loop and 4 alternating triangles, the first and second closed; third and fourth are confluent. M_3 well displaced to the lingual side of the jaw. The enamel of the alternating triangles is differentiated into thin and thick tracks. Length of lower tooth row (alveolar), 7 mm.; anteroposterior diameter of m_1, 3.3 mm.; transverse diameter of m_1, 1.3 mm.; approximate anteroposterior diameter of m_2, 2 mm.; transverse diameter of m_2, 1.3 mm.

This species is named for William K. McNown, who was a field companion for 4 years while employed by the Museum of Vertebrate Paleontology.

Museum of Vertebrate Paleontology, Kansas University, Lawrence, Kansas.

GENERAL NOTES

WILDLIFE'S TOLL OF A FOOD PATCH OF CORN

The value of standing unharvested corn (*Zea mays*), as an emergency food supply for wildlife is now widely recognized. Questions often arise concerning the extent to which animals use this food, the amount of grain damaged, and how much may be salvaged for other purposes in the spring. Throughout several past winters a food patch of 2.2 acres of unhusked corn has been left at the edge of a wildlife preserve consisting of 40 acres of deciduous trees and an adjoining small grove of conifers, belonging to Iowa State College. In mild winters, wildlife has not drawn heavily upon this food supply. During the winter of 1935–1936, with many continuous days of zero weather and heavy snowfall covering much other food, the animals used the emergency supply more liberally. Snow to a depth of nearly two feet lay on the ground of the patch of corn throughout most of the period from January 1 to March 20, 1936.

The most numerous mammals observed and taken at the field were the western fox squirrel (*Sciurus niger rufiventer*), Baird white-footed mouse (*Peromyscus maniculatus bairdi*), and Mearns cottontail (*Sylvilagus floridanus mearnsi*). Less numerous were the large short-tailed shrew (*Blarina brevicauda brevicauda*), northern white-footed mouse (*Peromyscus leucopus noveboracensis*), eastern meadow mouse (*Microtus pennsylvanicus pennsylvanicus*), house mouse (*Mus musculus musculus*), and brown rat (*Rattus norvegicus*). The Baird white-footed mouse was apparently most numerous and was easily taken in all parts of the corn patch, as readily without as with prepared bait. None of the white-footed mice were seen in the daytime, but in the morning, particularly after snowfalls, their tracks were everywhere apparent. The cottontails soon made rather definite paths as they moved through the field in their feeding. Fox squirrel tracks were most numerous very near the wooded edge. The squirrels gathered and carried ears of corn into the woods and fed largely on the hearts of the kernels. The starchy portions supplied food for a covey of bobwhites (*Colinus virginianus virginianus*), particularly in the early part of the winter. The fragments of kernels left by mice and rabbits on the snow and on the ground at the bases of the hills served as food for winter song birds.

In order to secure an estimate of the amount of damage to the grain in the field, each twenty-fifth hill of corn and the ground at its base were examined to determine the extent of loss of corn and which rodent was responsible. In most cases the size of the tooth marks in the kernels of corn, tracks in the snow, and droppings of the various animals that had visited each particular place rendered the diagnosis quite obvious, although in some instances there was doubt as to which sort of rodent did the most damage. The mice seemed generally to be the most thorough in their destruction and left few fragments on the ground; but in cases where the kernels were loose on the cob, as much as one-half ear might be left shelled on the ground or the snow. The rabbits left considerably more fragments on the snow than did the mice. In nearly every instance where the rabbits fed on the corn they left some whole kernels untouched. Probably the destruction by rabbits would have been less if the deep snow had not remained most of the winter to enable them to reach the corn as high as three feet above the ground. With less snow the mice, on the other hand, might have done but little less damage because it was found that they climbed the stalks in order to reach some of the ears of corn. Squirrels did by far the most damage in the limited area in which they fed. Some hills nearest the evergreen grove had every ear of corn removed from the stalks.

By calculation from the sampling of each twenty-fifth hill, it was estimated that the amount of corn eaten and wasted by cottontails was approximately 3 bushels, and approximately 1 bushel was charged against the mice. The squirrels took approximately 0.8 bushel.

The total yield of corn on the 2.2 acres was estimated to be 88 bushels. Game and song birds, squirrels, cottontails, mice and other rodents utilized approxmately 5.4 per cent of the yield. The remainder was husked in late winter and fed at the college barns. —George O. Hendrickson and Clifford Schlesselman, *Iowa State College, Ames, Iowa.*

OBSERVATIONS ON CRYPTOTIS FLORIDANA IN CAPTIVITY

On December 31, 1935, workmen moving a pile of dry bamboo and palmetto brush from the grounds of Bass Biological Laboratory in Englewood, Florida, uncovered four shrews. These were said to have been huddled together when the brush was removed. Two specimens were captured and placed in a wire cage, 30 × 14 × 12 inches, and kept in an unheated building. They proved to be *Cryptotis floridana*. One of the specimens lived 4 and the other 38 days. Except for a third individual (no. 130), taken in a mouse-trap February 3, 1936, I have seen no other *Cryptotis* from Englewood. Measurements, in millimeters, for specimens no. 79, 80, and 130, all males, are respectively as follows: Total length, ?, 72, 69; tail vertebrae, 19, 21, 18; hind foot, 10, 10.5, 10. Weights, ?, 4.97, 4.62 grams.

During the first four days, the two captive specimens were each fed between 4 and 5 grams of living mealworms (*Tenebrio* larvae) daily. During the next 33 days, following the death of the first specimen (no. 79), the remaining individual (no. 80) consumed no less than 3.5 grams of food in every 24-hour period, with a maximum of 8.1 grams and an average of 5.5 grams. Of course, the nutritional value of the food may have varied greatly.

While both shrews were together in the cage they lived in apparent harmony. No fighting was observed, although they frequently began eating at opposite ends of the same mealworm and they occupied the same nest. On the morning of January 5, however, one of the shrews was found dead and partly eaten. On the preceding day both had exhibited normal behavior.

The remaining shrew was found dead on the morning of February 8. On the preceding day it had appeared normal. On that day, however, through a miscalculation of the amount of food available, it had eaten only 1.4 grams. The weight of the specimen after death was 3.48 grams, a loss of nearly 30 per cent from its average live weight. I could find no other indication of the cause of death.

The following notes concern only the single specimen no. 80. Living mealworms were fed every day and comprised from 25 to 50 per cent of the shrew's fare. In addition, the shrew ate living waxmoths, ant lions, cockroaches (*Periplaneta*), a sphinx moth, crickets, small grasshoppers, various small beetles, pillbugs, parts of large ox beetle grubs, tree frogs (*Hyla squirella*), small-mouth toads (*Gastrophryne carolinensis*), lizards (*Anolis carolinensis*, *Eumeces inexpectatus*, and *Leiolopisma laterale*), and a nine-inch snake (*Tantilla* sp.). As already mentioned, the shrew either killed and partly ate its companion, or ate a part after it had died from other causes. Ground beef and parts of freshly killed *Peromyscus* were eaten only when left in the cage overnight. Fresh water was kept in the cage at all times and the shrew was seen to drink frequently.

Living oriental roaches (*Blatta orientalis*), millipeds (*Spirobolus* sp.), and snails (*Euglandina* sp. and *Planorbis* sp.) were refused. Carrots, lettuce, raisins, peanut butter, bacon, and rolled oats remained untouched even when left in the cage overnight.

The shrew habitually ate from one to one and one-half grams of mealworms, or about three-fourths of a gram of lizard, as a continuous process, but then refused food for a period varying between one and two hours. After that rest another lot would be taken when offered. I did not attempt to feed the animal the maximum amount it would eat over one twenty-four hour period.

Mealworms were merely seized and eaten with very rapid chewing. In attacking larger forms the shrew usually made a preliminary bite, apparently testing the quality of resistance. The attack continued as a series of bites, often delivered with great rapidity and well scattered over the victim. As soon as movement became feeble, eating began on some convenient part whether or not the prey was dead.

The shrew exhibited a definite technique in its attack on lizards. After the first skirmish, both *Eumeces* and *Leiolopisma* were seized by the tail and held until the member came off. Sometimes large *Eumeces* would drag the shrew about before the proper twist freed the tail. As the tail was always eaten before the shrew continued its attack, it might be assumed that an unconfined lizard would escape with only the loss of the tail.

Occasionally the shrew uttered a noise that I have recorded in my notes as resembling the call of a flicker heard at a considerable distance. The rapidly repeated sound was not excessively high and thin, although audible for only about 20 inches. This was not used as an alarm note.

The peculiar shrew odor was present at some times with considerable intensity, and almost absent at others. During the early part of its captivity and once again on February 1 and 2, this odor became strong enough to be perceptible at a distance of 10 feet or more.

Several experimental procedures arranged to test the senses of the animal failed to give any conclusive result.

I am indebted to C. C. Sanborn of the Field Museum for checking my identification of the specimens.—Stewart Springer, *Bass Biological Laboratory, Englewood, Florida.*

BATS HIBERNATE IN THE CENTER OF A LARGE CITY

In a Berlin afternoon paper, the Börsen Zeitung am Mittag, of November 21, 1935, there was a report that a zoologist, Hans Lohrl, discovered 100 or more bats of the species *Pterygistes noctula* under the eaves of a building containing the so-called Alte Akademie, Neuhauserstrasse, Munich. As we know but little of the hibernating habits of this common bat, Lohrl was most interested, and observed the bats daily from November 13, 1935, to March 7, 1936. He reported his findings in the Zeitschrift fur Morphologie der Tiere. The bats seemed to have a pronounced instinct for seeking and finding the warmest place available. In spite of the cold winter weather, the corner selected by the bats averaged a little above freezing, owing to the facts that the rooms in the building were all well heated and the main pipe of the heating apparatus was carried up in the corner itself. The corner was also exposed to as much winter sunshine as could well be expected. The bats seemed insensible to city noises and also were but slightly disturbed by snow or rain, but they evidently disliked sharp winds. Although there were variations, the majority of the bats slept for 4 days in November, 6 in December, 19 in January, the whole of February, and until March 7. The observer was obliged to discontinue his observations from March 7 to 12, and when he returned on the twelfth the bats had disappeared. It may be noted that in the beginning they retired to holes in the wall when the temperature was low, but later they slept outside, hanging under the eaves. In the course of the winter, 61 of the bats were banded with bands of the Zoological Museum, Berlin, and thus it will be possible this year to find out whether any have returned to this place of hibernation.—Theodor G. Ahrens, *Charlottenburg 2, Berlin, Germany.*

SOME FOOD HABITS OF THE BLACK BEAR

In the Jackson Hole-Yellowstone region, during the summer of 1935, grasshoppers and crickets were more abundant than usual. Autoists on the Cooke City highway leading out of Yellowstone reported that in the higher areas the dead bodies of crickets made the

road almost slippery. Grasshoppers and crickets are hard on vegetation, but the bears revelled in the insects, particularly the crickets, for these were the more abundant where the bears were active. The bears were observed feeding on these insects on August 23 on the high grassy ridges between Cache Creek and Miller Creek, and on the slopes north of Cache Creek, in the upper Lamar River region in Yellowstone Park.

The first day out we had to hurry to reach our destination so there was but little time for making observations. Also, for much of the time we followed streams, which apparently were not then frequented by the bears. We saw only a single bear and had but a glimpse of it as it entered a patch of timber. The second day we travelled in the timber up Miller Creek and saw neither bears nor bear sign.

We spent the third day wandering over the open park-like ridges examining the bison range. The hillsides were flecked with bison chips of all ages and I was astonished to see that hundreds of these had been tipped over by the bears. I tipped over several myself to see what they harbored, and found a cricket or two or a grasshopper under some of them. Only chips that had reached a certain age were potential hiding places for crickets, as the younger chips adhered too closely to the ground to afford any shelter.

During the day we saw 11 bears—6 adults and 5 cubs. At noon we saw the first, a mother and two cubs on a far hill-side feeding on the ground. About an hour later we approached the spot and found the adult still foraging. She slowly moved her nose over the ground, picking up a cricket every step or two and giving each one a few bites before swallowing it. There was no difficulty in catching the crickets, for the coolness of the day made them very inactive and sluggish. Most of the crickets were picked up in the grass, but some were taken under bison chips. With a paw the chip was delicately tipped on one edge and held poised while she peered beneath to see what was uncovered. The chips were probably turned over from force of habit gained in areas where such routine procedure was required to find food, for here the chips yielded but little compared to the number that could be picked up in the open. We approached within 50 yards of the bear before she discovered us. She emitted a hoarse snort that sent her two cubs scampering in unison, one on each side of the trunk, to the very top of a spruce. The mother continued to go through the motions of feeding until she had gained the edge of a grove, where she sat watching us.

On another hillside was an adult with a cub, and separated from them by several hundred yards was another lone adult. These bears were likewise searching over the open slopes for crickets and grasshoppers.

North of Cache Creek we frightened a lone bear at the edge of a grove and nearby found a fresh dropping composed of crickets and grasshoppers, which indicated that this bear also had been feeding on these insects. About one-half mile away there was still another lone bear, and a short distance beyond was a mother with two cubs. In the neighborhood of these four bears were a number of fresh bear droppings composed entirely of crickets and grasshoppers.

Scattered over the hillsides where the bears had been feeding lay many bear droppings. Most of them were relatively fresh, presumably not over two weeks old. Three droppings formed of grass were old and it is likely that they represented food eaten before the crickets became available. A total of 64 droppings were examined with the following results: 58 of them were composed entirely of crickets and grasshoppers, mainly the former; 3 contained crickets and grasshoppers with a small admixture of some berry, probably huckleberry; and 3 contained grass. The hard parts of the insects, such as the legs, ovipositor, and the head, were often entire, rendering identification very easy.

Apparently the bears in the hills at this time were living entirely on crickets and grasshoppers. It was thought by some that the bears had deserted the park garbage piles for the purpose of gorging themselves on these entomological sweets. If this were

true then the crickets and the grasshoppers must be given due credit for attracting the bears to the hills, for encouraging them to desert the garbage pile to live a clean out-of-doors life where bears are bears.—ADOLPH MURIE, *Wildlife Division, National Park Service, Omaha, Nebraska.*

SPOTTED SKUNKS AND BOBCAT

H. E. Anthony, in "Field Book of Mammals," stated in regard to the enemies of the spotted skunk, *Spilogale putorius*: "Rather free from molestation by predatory creatures because of its musk defense, but sometimes caught and eaten by the great horned owl and bobcat." In this connection the following observation may be of interest.

Last summer (1936), while camping in the Nantahala Mountains in western North Carolina, I chose to sleep on the front porch of the camp that was almost on a level with the ground. The little spotted skunks, *Spilogale putorius*, habitually played around on the porch, especially in the early evening, occasionally going into the camp to hunt for crumbs. There were at least one pair of adults and 6 kittens. Incidentally, this pair raised a second litter under the camp during August.

One bright moonlight night the kittens were unusually active and playful. In fact it was difficult to sleep on account of their patter and their inquisitiveness in standing on their hind legs and reaching up on the bed to sniff. I had lain awake some time watching them when I noticed across the road about 75 feet away a large bobcat, *Lynx rufus rufus*. He had jumped upon a fallen log and seemed to be watching the antics of the skunk kittens. Presently he sauntered slowly over to the cabin and sat down in front of the door. His position was directly in the line of patter of the kittens. In less than a minute, along came one of the skunks, nose toward the ground, and the thought flashed through my mind: "What happens when an irresistible force meets an immovable object?" At about eight inches from the bobcat, the skunk stopped short; obviously it had scented the cat. A moment's hesitation, and it trotted around the cat, back to its line of travel. The cat did not even so much as turn its head to watch the youngster.

Fully 20 times did the little skunks meet the cat, and every time the reaction was the same, with no attempt at escape. Sometimes the approach was from one side, sometimes from the other, but only once did the bobcat turn its head to watch a skunk. They were not in the least afraid of the cat, for repeatedly they ran up to him, only to stop, and then go around; in no case was a skunk observed to turn back and run away from the cat, and there was no indication of any fear. The attitude of the bobcat, translated into human terms, seemed to be that of utter disdain or contempt. After about ten minutes the cat sauntered away, leaving the skunks to continue their play.

The reaction of these two animals toward each other indicates that they certainly are not natural enemies. The skunks showed no signs of fright nor even of shyness, repeatedly returning to the cat, but never actually touching him. The bobcat, on the other hand, seemed to show little or no interest in the skunks, although at times they came within a very few inches of him. The mere fact that the skunks were not even watched indicates that they probably were of no interest to the cat, even as something with which to play.—WILLIAM H. GATES, *Louisiana State University, Baton Rouge, Louisiana.*

SPEED OF THE GRAY FOX

Because the running speeds of wild mammals are infrequently recorded, it seems desirable to report an observation made on the gray fox (*Urocyon cinereoargenteus*) on the evening of December 6, 1936. Andrew Du Pree, of the Cape Romain Wildlife Refuge, and I were traveling just after dark on a country road of fairly firm sandy soil between

Cain Hoy and McClellanville, South Carolina, when a gray fox jumped into the light beam some 35 feet in front of our car. I discovered shortly that we were gaining on the animal, so promptly slowed down to maintain a speed as near as possible to that of the fox. The maximum it was able to accomplish was 26 miles an hour, and it was not able to hold that speed for more than about 100 yards. Because there was a comparatively high bank or a ditch on either side of the road we were able to follow the animal at its full speed for more than one-half mile. After reaching a maximum of 26 miles an hour, the fox gradually slowed down, and by the time it left the road it was going at a rate of only 21 miles an hour. The horn of the car was kept blowing continuously to force the fox to travel at its maximum speed. While the road was of a sandy clay texture, it was damp from a recent rain, which made it compartively firm, even though it was not entirely smooth or exactly straight. So far as could be determined a uniform grade level was maintained.—CLARENCE COTTAM, *U. S. Biological Survey, Washington, D. C.*

A COYOTE IN HAMPSHIRE COUNTY, MASSACHUSETTS

In discussing the mammals of Hampshire County, Massachusetts, Crane (Jour. Mamm., vol. 12, pp. 267–273, 1931) implied the occasional presence of wolves in that locality but cited no records. Streever (Nat. Hist., vol. 38, pp. 156–161, 1936) referred to so-called mystery animals in northern New York, which proved to be coyotes. My attention was called to a newspaper notice recounting the taking of a wolf in the vicinity of Amherst, Hampshire County, in March, 1936, that also proved to be a coyote. Upon investigation the following facts seemed worthy of record.

A young farmer, whose land lies on the western edge of the Pelham Hills, experienced some losses of poultry, supposedly attributable to foxes. He set a trap and the next morning found therein a large mammal, which he killed with an axe and a gun. He skinned it and took the pelt first to a fur dealer in Springfield, Massachusetts, and later to the Hampshire County court house, to claim a bounty. The fur dealer pronounced the skin to be that of a wolf.

When I examined it, the carcass, which was that of a male, had been damaged so that measurements were impossible. This injury resulted from the method of killing and disposing of the animal. The skull was salvaged and cleaned, but other parts were quite useless. The pads of the feet had been removed and nailed separately to a board, several caudal and lumbar vertebrae were missing, and there was other damage. Both the trapper and I were impressed by the large size of the feet. The body was noticeably free from fat.

The skull was sent to the Bureau of Biological Survey and was identified as that of *Canis latrans*, but the sub-species could not be determined. The animal no doubt was an escaped individual. The condition of the pelt and the absence of fat suggested a season of poor hunting and perhaps a long distance travelled, and it is quite probable that this animal had been free for a considerable time. The roadside menagerie is a more or less common institution in New England, and a wide assortment of mammals are displayed at various filling stations, wayside parks, and other similar places. It is quite possible that this individual was freed from one of these sources.—H. E. WARFEL, *Amherst, Massachusetts.*

CERVICAL RIBS IN THE WOOLLY MONKEY

Cervical ribs rarely have been described in primates other than man. Hence it seems desirable to record their presence in two skeletons of the woolly monkey belonging to the U. S. National Museum. These specimens, studied during an investigation of the vertebral formulae of primates, were examined through the courtesy of Gerrit S. Miller, Jr.

In a juvenal male *Lagothrix infumata* (U. S. N. M. no. 238,260), from Para, Brazil, the seventh cervical vertebra carries a pair of short free ribs that fail to reach the sternum. These in general resemble the cervical ribs present normally on the ninth (and even eighth) vertebra of *Bradypus* and anomalously on the seventh vertebra of man. Similarly, the seventh cervical vertebra of a juvenal male *Lagothrix ubericola* (U. S. N. M. no. 238,309), from Rio Madeira, Brazil, possesses a very short free rib on its left side, but nothing suggesting such a structure on the right side. There is no trace of a cervical rib in 3 other examples of *Lagothrix* (1 *lagotricha*, 2 of unknown species) that also have been examined by me.

Cervical ribs, according to Le Double (Traité des variations de la colonne vertébrale de l'homme, Paris, vii + 543 pp., 1912), occur in about 2 per cent of men. As far as I can ascertain, they have been recorded in but two other primates.

Nayak (Note on an unusual type of cervical rib in a lemur, Jour. Anat., vol. 68, pp. 119–121, 1933) reported a specimen of *Perodicticus potto* in which the seventh vertebra possessed a pair of ribs reaching the manubrium sterni. This condition differs from that noted in *Lagothrix* but resembles the arrangement normal for *Choloepus*. A cervical rib does not occur in any of the 9 skeletons of *Perodicticus* (6 *potto*, 1 *edwardsi*, 2 of unknown species) that I have studied.

Schultz (Some distinguishing characters of the mountain gorilla, Jour. Mamm., vol. 15, pp. 51–61, 1934) stated that he had examined a skeleton of *Gorilla gorilla* (Mus. Comp. Zool., no. 25,949) in which the seventh vertebra had a well-developed rib on the right side. He did not mention whether it attained the sternum. This is a unique occurrence among the many gorilla skeletons that have been studied.

The apparent extreme rarity of cervical ribs in primates other than man likely is attributable to the fact that, customarily being small, they easily can be lost in preparing a skeleton. Furthermore, they need not produce a definite articular facet on the vertebra involved. Their occurrence therefore cannot always be demonstrated unequivocally in the event of their loss.—WILLIAM L. STRAUS, JR., *Department of Anatomy, The Johns Hopkins University, Baltimore, Maryland.*

NOTES ON MINNESOTA SQUIRRELS

During the early spring of 1936, opportunity was afforded the writer for spending considerable time in the coniferous forest area of northern Minnesota, particularly on one of the Forest Experiment Stations of the University of Minnesota, located near Cloquet, Carlton County. It was here that the subsequently described forage interrelationship between the red squirrel, *Tamiasciurus hudsonicus* ssp., and the yellow-bellied sapsucker, *Sphyrapicus varius*, was observed.

It had been previously noted that a small percentage of the red squirrels taken as specimens had their muzzles bedaubed with varying amounts of what appeared to be resin, but the exact nature of the method by which this was acquired was unknown. It was thought that perhaps it resulted from this animal's habit of clipping off the young tips of conifers. On April 22, 1936, however, certain phenomena were observed which lead one to suspect that the above is not the complete explanation.

On the above date, attention was attracted by the sounds attendant to typical foraging activities of *Sphyrapicus*. Closer observation revealed that a red squirrel was clinging to the trunk of a jackpine (*Pinus banksiana*) about two feet below the point at which the sapsucker was drilling. It appeared to be actively licking the liquid oozing from the holes made by the bird, but, aside from movement from one hole to another, there was little visible body movement except that of the tongue. Neither individual seemed to be paying the slightest attention to the other. The squirrel, when collected, proved to have daubed its muzzle rather thoroughly with the pitch upon which it had been feeding.

The writer is at present engaged in an ecological and natural history study of the gray squirrel, *Sciurus carolinensis hypophaeus*, and it has been found that in the spring of the year this subspecies may show something of the same type of appetite. The tree species involved is the Chinese elm, *Ulmus chinensis*, an ornamental shade tree being propagated in this region. During a certain short period in the spring, presumably after the sap has risen in the trees, grey squirrels may descend on the plantations in numbers and strip the bark from the region of the forks of the branches. It is assumed, for the present at least, that this behavior is the result of an urge to feed on the tree sap, although further study may point to other conclusions.—DONALD M. HATFIELD, *Economic Zoology, University of Minnesota, St. Paul, Minnesota.*

THIRTEEN-LINED GROUND SQUIRREL FEEDS ON WHITE GRUBS

In June and July, 1936, while working on the food habits of white grubs on the Huron National Forest, northeastern Lower Michigan, I found that individuals of *Citellus tridecemlineatus tridecemlineatus* fed readily on the live grub forms of June and related beetles.

For experimental purposes, hundreds of the larvae of these bettles were planted in one-gallon cans filled with soil and buried for almost their full depth in the ground. The ground squirrels learned that the grubs could be secured by digging several inches into the soil in the cans. Over 30 cans were thus raided, the grubs being removed and eaten by the squirrels. It is positively known that this amount of damage was done in a period of three days.

Two ground squirrels were taken in small steel traps set between rows of cans during the following week. A number of additional cans were raided during the interval. Although the traps were kept in operation for a month, only two squirrels were taken and not a single can was robbed of grubs after the second squirrel was caught, indicating that all damage was done by these two animals.

The two trapped animals were a male and a female, both extremely fat. The female was old and about 10 inches in length, being, therefore, a large specimen. The male was young and only about 7 inches long. The female contained no embryos, but the condition of the mammae indicated that she had recently suckled young.

Dissection of the digestive organs disclosed the head capsules and chitinized parts of many larvae. Among these identified were larvae of *Cotalpa lanigera*, *Aphonus tridentatus*, and several species of the genus *Phyllophaga*. Other species were eaten.

In the adjacent black oak-jack pine cover type and within 100 feet of the planted cans, 7 subterranean dens of ground squirrels were found. Other dens undoubtedly were present and it is known that there was a considerable ground squirrel population in the near vicinity. This indicates that the two squirrels taken may have learned by chance or by accident to dig for the planted grubs.—LEE E. YEAGER, *School of Forestry and Conservation, University of Michigan, Ann Arbor, Michigan.*

FOOD PREFERENCES OF ANTELOPE GROUND SQUIRRELS

The preceding remarks on *Citellus* by L. E. Yeager prompt me to offer some observations on the food of 5 captive *Ammospermophilus leucurus leucurus*, received through the kindness of Luther Little in October, 1935. In passing it may be remarked that during their first winter in captivity these animals were kept indoors, and they showed no tendency to hibernate. During their second winter the survivors have been kept in an unheated outhouse, and in addition to growing a particularly luxuriant coat of hair, they have been either completely lively, or else profoundly lethargic, approaching unconsciousness, for a day or two at a time but only occasionally, and apparently irrespective of the temperature.

The point that prompts this note, however, is that these ground squirrels are as omnivorous as any pig. They demand meat in no uncertain terms, and when it is given to them there must be enough to go around, or they fight viciously over it. Grubs, grasshoppers, chop bones, are pounced upon with avidity. They have proven to be peaceable, one with another, except when meat is furnished in insufficient quantity or frequency, when one individual is killed and partly consumed, until now there is left only one, the most belligerent member of the quintet.

The food habits of this genus could hardly prove to be of economic importance, but it is hoped that this note will arouse the interest of some economic mammalogist in investigating the relationships of the smaller sciuromorphs to the insects that they use as food.—A. Brazier Howell, *Johns Hopkins University, Baltimore, Maryland.*

MICROTUS PENNSYLVANICUS IN COASTAL SOUTH CAROLINA

The presence of meadow mice in coastal South Carolina was first revealed in 1934, when the writer recorded (Jour. Mamm., vol. 15, pp. 253–254, 1934) finding the remains of a number of these rodents in a series of barn owl pellets that had been collected in Charleston County by E. B. Chamberlain, of the Charleston Museum. Previously the known southern distribution of meadow mice along the Atlantic coast extended only to northern North Carolina, and as far as known there were none of these animals anywhere in tidewater South Carolina.

Late in 1936, an opportunity was afforded to make a further check on the occurrence of meadow mice in South Carolina by studying additional pellet material of the barn owl. This was made available through the efforts of Andrew Du Pre, superintendent of the Cape Romain Migratory Bird Refuge, who had discovered, early in November, a barn owl nest in a steel observation tower in process of construction on the refuge. The tower was out in a salt marsh regularly covered by high tide and was perhaps two and one-half miles from the nearest point of dry land. A series of twenty-one complete pellets was collected from the nest for food examination. Detailed study of this material revealed the remains of 7 *Microtus pennsylvanicus*. Other species represented included the rice rat, Virginia rail, clapper rail (?), and seaside sparrow. This again indicates the presence of this rodent in the eastern part of the State.

Mr. Chamberlain has endeavored to trap specimens of meadow mice from the Santee region, but without success, and material is still lacking for subspecific determination of the coastal meadow mouse in this region. The species apparently is well established as a resident mammal near the mouth of the Santee River, however, and it is probable that it occurs at other points farther north along the South Carolina coast.—A. L. Nelson, *U. S. Biological Survey, Washington, D. C.*

HOUSE RAT IN A BANK SWALLOW'S NEST

In his recent paper "The house rat as an enemy of the bank swallow," in the last number of the Journal of Mammalogy (vol. 18, p. 87), Dr. Dayton Stoner stated that he was unaware of a previous record. Mr. Norman De Witt Betts and I killed a rat occupying a nest in a colony of bank swallows on the Yahara River, near Madison, Wisconsin, May 29, 1914. A brief note on the occurrence was published by Mr. Betts in Bird-Lore (vol. 16, p. 283, 1914). My field notes state that it was "a common brown rat about one-half grown."—A. W. Schorger, *168 North Prospect Avenue, Madison, Wisconsin.*

REVIEWS

Brewster, William. OCTOBER FARM, from the Concord Journals and Diaries of William Brewster with an introduction by Daniel Chester French, edited by Smith O. Dexter and with a foreword by T. Barbour. Harvard University Press, Cambridge, Massachusetts, i–xv, 1–285, frontispiece. 1936. Cloth, $2.50.

The inscription by Doctor Thomas Barbour, "I was afraid you might not see this", in a copy of October Farm sent to a friend, might apply to all readers of the book; for I think it is Dr. Barbour to whom we are indebted for the appearance in published form of these excerpts from the journal of this late naturalist, most widely known as an ornithologist.

The accounts cover the period from 1872 to 1919, and those written progressively later reflect the increasing maturity of the mind of a naturalist who found rare pleasure in observing the behavior of his "lower" animal associates, here about Concord at some of the very places that readers of Thoreau know so well. The accounts are so delightfully written that the book holds one's attention to the very end.

Even those who know most about the life histories of New England mammals will find facts new to their stores of knowledge in the material relating to 18 species found about Concord. The careful account of the nest and "flight" of the flying squirrel, the detailed recording of the calls and behavior of the muskrat, the information on the food of the striped skunk, the descriptions of enemies of meadow mice and deer mice, are supplemented by observations on mink, weasel, fox, large brown bat, shrew, Norway rat, chipmunk, red squirrel, gray squirrel, woodchuck, cottontail, and deer.—E. RAYMOND HALL.

WILDLIFE RESTORATION AND CONSERVATION. Proceedings of the North American Wildlife Conference called by President Franklin D. Roosevelt, Washington, D. C., February 3–7, 1936. Biological Survey Edition. U. S. Government Printing Office, 1936, 675 pp.

Attention should be called to this volume, illustrated with 77 plates and substantially bound in buckram. A review of its contents is hardly feasible, for it consists of all the papers presented at the conference, together with the accompanying discussions. On the whole the papers are of excellent quality and biologically sound. To the reviewer, however, the interesting point about the volume is that it presents a cross-section, not of the conditions that face American wildlife today, but of the problems that confront chiefly those who make their living out of tending, investigating, or exploiting game. Those who are interested in the subject will wish to have the report on their shelves, for it should, in future years, be of considerable historic value.

Like the text, most of the illustrations are of high grade, but they are not uniformly commendable. Unfortunately there are pictures of a dead porcupine and a dead snowshoe hare, both propped in poses calculated to deceive the observer. In addition, pictures of bald eagle and bobcats are almost certainly of mounted specimens placed amid natural surroundings, and that of the gray fox looks very suspicious. These five photographs are from the Forest Service, and the legends do not disclose the true state of affairs. It may be claimed that these photographs are of little moment in a book of this nature, but honesty in illustrations is as desirable as honesty in text. Certainly the Forest Service is in some respects a scientific bureau, and one does not like to have to scrutinize all of their published photographs with the question in mind that they may be faked.—A. BRAZIER HOWELL.

Young, Stanley P. RODENT CONTROL AIDED BY EMERGENCY CONSERVATION WORK. United States Department of Agriculture, Bureau of Biological Survey, Wildlife Research and Management Leaflet BS-54. December, 1936.

This leaflet is, as indicated by the title, an encomium of the part the E. C. W. has played in rodent control of all sorts. The species concerned are prairie dogs, ground squirrels, pocket gophers, kangaroo rats, rabbits, and porcupines.

The first section, pages 1–6, concerns itself with a general discussion of the aspects of, and need for, control, with emphasis upon forest and forage protection, and soil conservation. The second section, pages 7–30, presents " . . . better than would volumes of written words, the story of rodent damage and of cooperative work to reduce this damage."

One cannot help but admire the author's presentation of the "facts." An analysis of some of these, however, leads one to some doubt of their validity. For instance, on page 2, under the heading "Training of E. C. W. Crews," the author states, "The boys liked to work in these [rodent control] crews, as it afforded them opportunity to become acquainted not only with methods of rodent control *but with the various habits of wildlife as well.*" (Italics mine.) There is no doubt that acquaintance with the various habits of wildlife is a valuable asset during these days of increasing leisure, but my experience with E. C. W. control crews in southern Oregon during the summer of 1935 convinced me that the acquisition of such knowledge was incidental—so incidental as to be infinitesimal in 49 cases out of 50. I question the soundness of training enrollees in wholesale destruction of mammals which have biological uses that may prove, and in some instances have proved, to overbalance the damage that they may do.

In the second paragraph under the same heading, the author states that, if crews be properly supervised, there is little danger of the accidental poisoning of other animals. This statement may be true, although it would appear that, with the present field instructions issued to supervisors, there may be more than a little danger, even though the work is properly supervised. It must be admitted, too, that there is often a vast difference between administrative recommendations and actual field practice. Poison-coated grain is still being broadcast from horseback in some sections of the country.

Under the heading "Timeliness of Emergency Aid," the author states that "Livestock and rodents together . . . caused the beginning of sheet erosion in areas where there would still be ample forage for livestock had it not been for the excessive numbers of rodents." The validity of this assertion cannot but be questioned. Extensive observation has firmly convinced me that overgrazing by stock, particularly sheep, has done most of the damage. This conclusion has been reached through a comparison of areas, both slopes and meadows, in the ponderosa pine type, where presence or absence of rodents appeared to have little if any effect on the extent of the dust beds resulting from overgrazing. It may be that "Damage in some instances has amounted to at least 75 per cent of the available forage. . . . " I have seen areas upon which it approached 100 per cent, where no so-called injurious rodents existed, or so far as I could determine, had existed, in the immediate past, but where sheep had grazed or trampled nearly all the available forage. Surely, tacit agreement that rodents are the major factor in this denudation is likely to lead not only to useless poisoning campaigns, but also to useless waste of Federal appropriations.

Under "Examples of Benefits Derived," the author asserts that "The control work carried on by an E. C. W. crew near Weber Lake, Calif., in 1933 has been responsible for a 50 per cent comeback of the grass on a large mountain meadow, which had been made a dust heap because of pocket gopher workings. The pocket gophers had honeycombed the surface of the ground, and *sheep had trampled out most of the grass*, while livestock grazing had been reduced to a negligible figure. *The restoration in two years was due primarily to the elimination of the pocket gophers.*" (Italics mine.) The author neglects to state whether or not the grazing had been curtailed during the two years; he gives the reader a rather incomplete picture.

The work of the Bureau of Biological Survey, in so far as it aids in the protection of harmless and beneficial species, is laudable, but it appears that there are interrelating factors involved here that are not as yet clearly understood. We know, for instance, that some of our more valuable fur bearers feed to a great extent upon rodents. Are we then protecting and "managing" these fur bearers to the best advantage if we attempt to remove their food supply? Certainly not when this food supply is still regarded by many investigators as being but doubtfully injurious in character.

The problem seems to resolve itself into a careful balancing of *all* the factors involved, on the basis of research, and then proceeding cautiously with an eye to the future—a difficult feat when immediate action of a more spectacular type is demanded.

Incidentally, the theory might well be advanced at this time that probably one of the most important factors accounting for the present overabundance of rodents and the consequent need for local control has been the indiscriminate predator control activity of the last decade, and the practical removal of one of the most valuable aids in the natural control of rodents—the predatory fur bearer.—DONALD M. HATFIELD, *Economic Zoology, University of Minnesota, St. Paul, Minnesota.*

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OBITUARY NOTICES

CHARLES VICTOR NOBACK

Charles Victor Noback was born in New York City, March 2, 1888. He received the degree of Doctor of Veterinary Medicine from Cornell University in 1911. Following a visit to Europe, where he studied the methods of sanitary control of meat, water and milk supply in several cities, he entered the service of the United States Bureau of Animal Industry, and a year later began his work in food and milk inspection and the preparation of vaccines and anti-toxins in the Division of Laboratories and Research of the Health Department of New York City.

In 1920 he went to the National University at Bogota, Columbia, South America, as Professor of Comparative Pathology, and acted as consulting veterinarian in tropical diseases to the Laboratorio de Heigeina. In 1923 he returned to Cornell University, where he pursued graduate studies in comparative pathology and biochemistry, and collaborated with Professor J. B. Sumner on the studies which resulted in the isolation of the first pure enzyme,—urease. He received the degree of Doctor of Philosophy in 1925. In 1926 he served as State Assistant Bacteriologist in the New York State Division of Laboratories and Research at Albany, and later in the same year he was appointed Veterinarian and Pathologist of the New York Zoological Society, a post that he occupied until his death. At the Zoo his interest in the diagnosis and treatment of the diseases of animals, their nutrition and care, found its fullest and most fruitful expression. The extraordinary tenderness and sympathy with which Dr. Noback treated his charges can never be forgotten by anyone who has had the privilege of seeing him at work. The demands put upon his time by the animal population of the Zoo were great, yet he was able to carry out a number of scientific studies of value. His work on the gross and microscopic seasonal changes in antlers, the direct bone formation in antler tines, and the growth changes of the carpal bones and digital epiphyses in the infant gorilla are well known. His untimely death interrupted his researches on the relationship of the endocrine organs and blood chemistry of the growth of antlers in the deer, as well as studies on the development of the external genitalia and their changes in form in relation to the menstrual cycle in the female gorilla. The latter study was an important piece of work upon which he had long been engaged, and which now is being continued by his son Charles R., who was his collaborator in this research.

Dr. Noback devoted much time and energy to the civic affairs of the community in which he lived at Scarsdale, New York, especially as a member of the local school board. He was a fellow of the American Association for the Advancement of Science, the New York Academy of Sciences, and the New York Zoological Society; he was a member of Sigma Xi, The American Society of Mammalogists, the American Association of Physical Anthropologists, the Harvey Society, and he was President of the Veterinary Medical Association of New York City, President of his Alumni Association, and Captain in the 102nd Medical Regiment.—GUSTAVE J. NOBACK.

FREDERIC HEDGE KENNARD

Frederic Hedge Kennard, a life member of the American Society of Mammalogists, died after a brief illness on February 24, 1937, in his seventy-second year. He was born in Brookline, Massachusetts, on November 19, 1865, the son of Martin Parry and Caroline Augusta (Smith) Kennard, and continued to reside in that town until his death. As a lad he early showed a natural love for the out-of-doors and a keen interest in animal life, which, as so often is the case, found expression in the collecting of eggs and later, in a more serious way, bird skins and mounted specimens. He graduated from Harvard

in 1888, and for a time continued his studies at the Bussey Institution and the Lawrence Scientific School of that University. In 1896 he entered upon his career as a landscape architect, but retired from active practice in 1916. He was married in 1896 to Sarah Harrison Eisenbrey of Philadelphia, who, with their daughter and four sons, survive him. Although he published little on mammals beyond a few brief notes, his general interest in the native fauna was wide. He was an enthusiastic supporter of Ernest Harold Baynes in his successful efforts to preserve the American bison from extinction, and it was in great part due to his energetic backing that a course on the natural history of birds and of mammals later was developed at Harvard. A few years before his death he gave his large collection of bird skins to the Museum of Comparative Zoölogy, and his nests and eggs of New England birds to the New England Museum of Natural History at Boston. In his later life he was able to make occasional journeys for collecting or for pleasure to the South or the West, and once to Panama, chiefly for the collection and study of birds. The hospitality of his beautiful estate in Brookline was known to many visiting naturalists.—G. M. ALLEN.

WILLIAM TEMPLE HORNADAY

Wild life of the world lost its most militant defender on March 6, when William Temple Hornaday died at his home at Stamford, Connecticut. The first director of the New York Zoological Park and the Director Emeritus since 1926, he was 82 years old, and until the last week of his life was still employing his pungent pen in defence of mammals and birds that he believed were threatened with extinction.

Doctor Hornaday was born near Plainfield, Indiana, on December 1, 1854, and attended Iowa Agricultural College. He decided upon a career as a taxidermist, however, and after preparation at Ward's Natural Science Establishment in Rochester, New York, he made his first collecting expedition to Cuba and the West Indies in 1874. Subsequently he collected specimens in South America and then spent three years in India, Ceylon, the Malayan peninsula and Borneo, from where he brought back a collection said to be the finest made by one man up to that time.

In 1880 he founded the National Society of American Taxidermists, and two years later was made chief taxidermist for the U. S. National Museum, remaining there until 1890.

He was instrumental in creating the National Zoological Park and was its superintendent for a time, but resigned when his ideas clashed with those of Congress. For the next six years he tried selling real estate in Buffalo, but they were unhappy years and he was delighted in the spring of 1896 when the New York Zoological Society asked him to direct the zoological park that was about to be established.

From April 1, 1896, to June, 1926, he directed the development of the park and at the same time carried on his "thirty years' war for wild life." The latter, however, did not end when he retired and was succeeded as director of the Zoological Park by Dr. W. Reid Blair, for from his home and office in Stamford he continued the war through the Permanent Wild Life Protection Fund, a separate, militant conservation organization which he was largely instrumental in founding.

The Bayne Law, which prohibited the sale of native game, was largely the result of his efforts, and he gave unremitting support to the Tariff Law of 1913, which prohibited the importation of wild-bird plumage for millinery purposes. One of his first campaigns, before the federal government became active in conservation, was to petition the legislatures of the 48 states to enact laws limiting the daily bag of game birds. Eight of them acceded to his plea.

No major nor even minor conservation measure of the last third of a century escaped his careful scrutiny, and by pamphlet, letters, telegrams and speeches he fought for most

of them. No person was too powerful and no position too entrenched for him to attack, if he thought the cause of wild life required it.

As one commentator expressed it: "Dr. Hornaday . . . never seemed to care whom he made his enemy so long as the wild tern, feeding at peace along the banks of some lonely creek, called him friend."

Two years before his death he summed up his active career with the statement: "I have seen the American bison saved from total extinction. I have seen the fur industry of Alaska saved. But we haven't caught up with the front line of the guns."

In recent years a large part of his fire was concentrated against the makers of guns and ammunition, whom he charged with responsibility for hunting regulations that were, to his mind, far from sufficiently drastic. He was particularly vigorous in his demands for a completely closed season on waterfowl.

In recognition of his work in natural history and conservation, he was decorated by the British, French and Belgian governments. In 1907 he received the first gold medal of the Camp Fire Club of America, and he was a patron and fellow of the New York Zoological Society, an honorary member of the Philadelphia Zoological Society, and of the Society for the Preservation of the Fauna of the Empire.

Among his books were "American Natural History," "Taxidermy and Zoological Collecting," "Our Vanishing Wild Life," "Tales from Nature's Wonderland," "Minds and Manners of Wild Animals," "A Wild Animal Roundup," "Wild Animal Interviews," and "Wild Life Conservation in Theory and Practice."—W. Reid Blair.

WILLIAM FREDERIC BADÈ

In the death of William Frederic Badè at Berkeley, California, on March 4, 1936, the cause of conservation has lost a notable advocate. This fact is attested by Dr. Badè's service as president of the California Associated Societies for the Conservation of Wild Life, and as vice-president of the Society for the Preservation of National Parks.

Dr. Badè was a member of many organizations, scientific, literary, and social. His interest in the out-of-doors and his membership in the Sierra Club resulted in a close friendship with John Muir, whose literary executor he became, editing many of Muir's manuscripts and publishing a book, the "Life and Letters of John Muir." His bibliography contains the titles of many articles contributed to leading magazines on archeological and Old Testament themes, in addition to the published results of his five archeological expeditions to Palestine. His interest in the study of birds and mammals led Dr. Badè to join the Cooper Ornithological Club in 1903, the American Ornithologists' Union in 1916, and the American Society of Mammalogists as charter member in 1919.

Born in Carver, Minnesota, on January 22, 1871, Badè was the son of William Burns and Anna Voigt Badè. Graduated from Moravian College, Pennsylvania, in 1892, he received his Ph.D. degree from his Alma Mater in 1898. Meanwhile, he had received the degree of Bachelor of Divinity from Yale University in 1895. From 1896 until 1902, he taught at Moravian College. In the latter year he became professor of Old Testament Literature and Semitic Languages at the Pacific School of Religion at Berkeley, California, a position which he held throughout the remainder of his life.

Dr. Badè was married in 1906 to Evelyn Marianne Ratcliff, whose death occurred the following year. A daughter, Mrs. Evelyn Mary Gulick, survives her parents. In 1917 he was married to Elizabeth Le Breton Marston, who with their two children, Elizabeth Le Breton and William George Badè, survive him.—H. W. Grinnell.

NOTES AND NEWS

But little dependability can be placed on newspaper accounts concerning wildlife. Occasionally, however, something informative is encountered. Recently, an item was noted in the Baltimore Sun recounting the fact that a small shipment of live rabbits from Missouri had been liberated on the bank of a river in southern Maryland. Note was taken of the circumstance that all but one of these animals hopped into the brush, but the exception bodly entered the water and swam strongly to the opposite shore. So it would seem that there is at least one swamp rabbit (*Sylvilagus aquaticus*) in Maryland. This item suggests that one should view with skepticism the occurrence of the swamp rabbit, or indeed any other sort of lagomorph, outside of its regular range. The statement applies to numerous other mammals as well. The editor is convinced in his own mind that he saw an individual of *Eutamias* cross a road last fall in the environs of Baltimore. If so this animal must have escaped from captivity.

Contributors are expected to order desired reprints of their articles on the printed form supplied for this purpose when galley proof is sent to them. Several misunderstandings have arisen from the casual ordering of reprints by letter at the time that papers were submitted, and the editor cannot be responsible for reprints desired but not ordered in the regular manner, although he will endeavor at all times to coöperate with contributors to the best of his ability.

It has, perhaps, been generally believed by contributors that articles of more than 10 or 15 pages in length would not prove acceptable for the JOURNAL. The JOURNAL, however, is now substantially larger than in recent years and can be further enlarged if longer and more numerous articles become available. There is always a dearth of contributions of general interest, particularly of a length of 10 or more pages. If acceptable articles of this type are not received in sufficient quantity, there must be published a disproportionate percentage of technical papers.

MEMBERSHIP

Anyone interested in any phase of mammalogy is eligible for membership in the American Society of Mammalogists, and if elected will receive the Society's official publication, the Journal of Mammalogy, quarterly. Name and address, with remittance of $3.00 for annual dues, may be sent to the Corresponding Secretary, or to any officer of the Society. Membership is dated from the nearest January, although formal election will not take place until the annnal meeting of the Society following the receipt of application.

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William H. Burt, *Corresponding Secretary*
Museum of Zoology, University of Michigan, Ann Arbor, Mich.

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